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Philippine Normal University
National Center for Teacher Education

**DEVELOPMENT OF A STE[Arts]M EDUCATION FRAMEWORK FOR
SENIOR HIGH SCHOOL STEM STRAND**

A Dissertation Presented to the Faculty of
The College of the Graduate Studies and Teacher Education Research
Philippine Normal University
The National Center for Teacher Education
Manila

In Partial Fulfillment
of the requirements for the Degree of
DOCTOR OF PHILOSOPHY IN SCIENCE EDUCATION

Lexter R. Natividad

January 2022



Philippine Normal University
National Center for Teacher Education

APPROVAL SHEET

This dissertation entitled “**DEVELOPMENT OF A STE[Arts]M EDUCATION FRAMEWORK FOR SENIOR HIGH SCHOOL STEM STRAND**” prepared and submitted by **LEXTER RAMUYAN NATIVIDAD** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy (Ph.D.) in Science Education**, is hereby recommended for approval and acceptance.

MARIE PAZ E. MORALES, PhD
Adviser

Approved in partial fulfillment of the requirements for the degree **Doctor of Philosophy (Ph.D.) in Science Education** by the Oral Examination Committee.

ARLYNE C. MARASIGAN, PhD
Chairperson

CRIST JOHN M. PASTOR, PhD
Member

ALI G. ANUDIN, PhD
Member

ALLEN A. ESPINOSA, PhD
Member

Accepted in partial fulfillment of the requirements for the degree **Doctor of Philosophy (Ph.D.) in Science Education**.

Date

MARILYN U. BALAGTAS, PhD
Dean
College of Graduate Studies and
Teacher Education Research



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LEXTER R. NATIVIDAD



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DEDICATION

*I dedicate this work to
My Mother who has given me life, unconditional love,
and infinite support to experience the countless beautiful
realism that is shifting into new chapters and even my new
stories in which I never thought I would ever enjoy or
have the privilege of knowing
with all my Love.*



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ABSTRACT

Name: **Lexter R. Natividad**

Title: **DEVELOPMENT OF A STE[Arts]M EDUCATION FRAMEWORK FOR SENIOR HIGH SCHOOL STEM STRAND**

Key Concepts: **STEM Education, STEAM Education, Framework, Senior High School, Training Design, Indicators and Standards**

Degree: **Doctor of Philosophy in Science Education**

Adviser: **Dr. Marie Paz E. Morales**

Novel and sophisticated educational approaches continually emerge to promote scientific literacy related to 21st century skills and future skills to achieve quality science education. In the Philippines, the need for a new educational approach has become more pronounced as the country's ranking in the PISA is getting way behind, and competent STEM professionals are relatively few. Across the globe, other countries are implementing the so-called STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education to boost their STEAM pipeline. In the Philippines, however, the implementation of STEAM education appears to be challenging. On top of the perceived challenges and barriers is the need for contextualization. Addressing this gap, this study developed a STEAM Education framework for senior high school (SHS) STEM strand. Sequentially, the study produced a model training design, and indicators and standards as validation products of the framework.

The study employed Strauss and Corbin (1990) grounded theory approach in three phases: analysis phase, framework development and validation (experts' content validation) phase, and development and validation of training design and indicators and standards phase. The participants were senior high school (SHS) science teachers in the STEM strand and their corresponding administrator or principal. To have representative participants for each type of senior high school offering STEM strand in Nueva Ecija, stratified purposive sampling along with theoretical sampling was used. The semi-structured interview was utilized as one measure and data source. Interview transcripts were coded using open, axial, and selective coding and the generated themes were used to develop the STEAM Education framework. The developed framework was validated by a panel of experts using the *Delphi technique*. The training design, indicators, and standards were sourced out from the developed framework as second-tier validation of



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the developed STEAM Education framework. These products were validated by the same panel of experts using the Delphi technique. Data validation was conducted through member checking, triangulation, intercoding, and checking of researcher's bias. Protocols were observed properly to conform to the ethical standards.

Results revealed that the needs and constructs of SHS STEM strand from different types of high school in Nueva Ecija on the lens of teachers and administrators in pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, among others for the implementation of STEAM Education are centralized on eleven themes. They are *teachers' qualifications, competencies, pedagogical characters, STEM curriculum refinement, discipline integration, administrator' leadership and management, student' skills, assessment practices, safe learning space, policy reorientation and harmonization, and partnership and support*. A framework from these themes was developed and validated. The validated framework highlighted the importance of the roles of different stakeholders such as teachers, administrators, curriculum experts, policy makers, learners, parents, and the community in producing a holistic STEAM curriculum.

A set of standards and indicators and training design were derived from the framework and validated. Using the validated training design, a six-day training program for STEM teachers and a five-day training program for administrators were proposed. The training matrix for teachers comprises nine modules while for administrators, it comprises ten modules. A maximum of six hours of participation per day is expected if the training program is implemented.

Anchoring from the validation results of the framework and the training design and set of indicators and standards, a national scale validation, obtaining consent and approval from DepEd, implementation of the said outputs, crafting policies and guidelines for operationalization, conducting capacity building, and developing pre-service STEAM Teacher Education Curriculum are the future endeavors for the developed STEAM Education Framework for Senior High School STEM Strand.



Philippine Normal University

National Center for Teacher Education

TABLE OF CONTENTS

TITLE	PAGE
TITLE PAGE	i
APPROVAL SHEET	ii
ACKNOWLEDGMENT	iii
DEDICATION	vii
ABSTRACT	viii
TABLE OF CONTENTS	ix
LIST OF TABLES	xiv
LIST OF FIGURES	xvi
LIST OF APPENDICES	xix
CHAPTER 1 THE PROBLEM AND LITERATURE REVIEW	1
Background of the Study	1
Literature Review	8
Quality Science Education	8
Science Teaching, 21 st Century Skills, and Future Skills	12
STEM/STEAM Education	16
STEM Education	16
STEAM Education	22
Philippine STEM Workforce and STEAM Education	29
Challenges and Barriers in Implementing STEAM Education	34
The Philippine Basic Science Education and the K to 12 Curriculum	37
Senior High School (SHS) STEM Strand	42
Conceptual Framework of the Study	48
Research Questions	53
Significance of the Study	54
Scope and Limitations of the Study	56
Definition of Terms	57
CHAPTER 2 METHODS	59
Research Design	59
Research Settings	62
Sampling and Participants	64



Philippine Normal University

National Center for Teacher Education

Procedures	74
Phase 1: Analysis	77
Development of the Interview Guide	78
Data Collection	85
Field Notes, Case Summary, and Memoing	90
Constant Comparison Method and Coding	96
Data Validation, Reliability, and Researcher's Bias	104
Phase 2: STEAM Education Framework Development and Validation	107
Development of STEAM Education Framework	107
Validation of the developed STEAM Education Framework	109
Phase 3: Development and Validation of Training Design and Indicators and Standards	113
Ethical Considerations	114
 CHAPTER 3 RESULTS AND DISCUSSIONS	 116
Needs and Constructs of SHS STEM Strand in different parameters	117
Profile of Participants and Related Details	118
Different Constructs and Needs on STEM Strand of Teachers and Administrators	124
Themes from the grounded theory and the emergent STEAM Education Framework	130
Different Codes, Categories, and Themes generated from the Grounded Theory	130
Teachers' Qualifications	140
Teachers' Competencies	145
Subject – Matter Competency	146
Lifelong Learning Competency	149
Technological Competency	152
Research Competency	156
Communication Competency	158
Social – Emotional Competency	161
Teacher Pedagogical Characters	164
Communicating Teacher	166
Engaging Teacher	168
Transforming Teacher	172
STEM Curriculum	175
Comprehensive yet congested	178
Work-oriented yet very idealistic	183
Well-designed yet problematic	185
Discipline integration	191
Character education subjects	192
Other science – related courses	193
Arts integration	193



Philippine Normal University

National Center for Teacher Education

Administrators' Leadership and Management	198
Sound Administration	199
Effective Management	205
Transformative Leadership	207
Student Skills	210
Innovative Individual	213
Critical Thinker	213
Creative Person	214
Reflective Learner	215
Assessment Practices	216
Safe Learning Space	222
Policy Reorientation and Harmonization	232
Entrance Exam	234
STEM Students switching strand and to non-science courses	236
Non – board passer teachers	240
Teachers handling many courses and misalignment of subjects with their specialization	244
Harmonization of subjects	247
Support and Partnership	251
Institutional Support	252
Parent Involvement	254
Community Partnership	257
Emergent themes in relation to STEAM Education	261
The Emergent Grounded Theory: STEAM Education Framework	275
Standards of the Framework	281
Validated Framework, Standards and Indicators, and Training Design	285
Validation result of the emergent grounded theory	287
The validated grounded theory	293
Standards of the Framework	298
Set of Indicators	302
Training Design	312
Teacher Professional Development Program	312
The Developed Training Design	316
Training Content and Objectives	317
Training Modality	323
Audience and Learning Styles	326
Training Matrix	328
Validation result of Training Design and set of Indicators and Standards	335
Validated Training Design and Set of Indicators and Standards	345
Way Forward	356
 CHAPTER 4 SUMMARY, CONCLUSION, AND RECOMMENDATIONS	 360
Summary	360



Philippine Normal University

National Center for Teacher Education

Findings	362
Conclusions	369
Recommendations	371
 REFERENCES	 373
 APPENDICES	 417
 CURRICULUM VITAE	 557



Philippine Normal University
National Center for Teacher Education

LIST OF TABLES

TABLE NUMBER	TITLE	PAGE NUMBER
1	The schedule of specialization subjects for students who are in STEM Strand	44
2	The number of SHS offering STEM Strand per classification and per division in the province of Nueva Ecija	66
3	The number of SHS offering STEM Strand that was randomly selected per division in the study	69
4	Individual profile of interviewed teacher-participants	72
5	Individual profile of interviewed STEM administrators	73
6	Intended deliverables in each phase of the study	74
7	Interview questions for STEM teachers	79
8	Interview questions for administrators	81
9	Frame of the conducted interview	89
10	Overview of the stages/phases, instruments, type of instruments, and participants in the study	114
11	The general profile of interviewed STEM teachers	119
12	The general profile of interviewed STEM administrators	121
13	Needs and Constructs emanated from the interview responses	125
14	Sample open, axial, and selective codes derived from the responses of the participants	131
15	The number of open and axial codes to produce each theme	137
16	Criteria for admission of students in different SHS Tracks/Strands	235



Philippine Normal University

National Center for Teacher Education

17	Subject Offerings of Some Schools in Nueva Ecija for STEM Grade 11 1st Semester	249
18	Summary of suggestions of validators for the developed framework and the researcher's action	287
19	The result of validation in terms of content and organization of the framework.	290
20	The result of validation in terms of relevance and usability of the framework.	291
21	The result of validation in terms of aesthetics and presentation of the framework.	292
22	The standards and indicators sourced from the validated STEAM Education Framework for SHS STEM Strand	303
23	The proposed training module and its specific learning goals.	318
24	The Proposed Training Matrix for STEM Teachers	330
25	The Proposed Training Matrix for STEM Administrators	333
26	Summary of suggestions of validators for the developed training design and set of indicators and standards and the researcher's action	339
27	The result of validation for training design	342
28	The result of validation for indicators and standards.	344
29	The validated set of standards and indicators.	345
30	The Validated Proposed Training Matrix for STEM Teachers	351
31	The Validated Proposed Training Matrix for STEM Administrators	354



LIST OF FIGURES

FIGURE NUMBER	TITLE	PAGE NUMBER
1	Partnership for 21 st Century Learning (P21) Framework for 21 st Century Learning	13
2	Map of Future Skills	14
3	Yakman (2010, 2015) Framework for STEAM Education	23
4	The Philippine STEAM Education Model	33
5	K to 12 Framework of Science Education	40
6	The tracks and eight core learning areas of the Senior High School Curriculum	43
7	Conceptual Framework of the Study	52
8	Map of Nueva Ecija showing (a) its neighboring provinces and (b) congressional districts	62
9	The five DepEd Schools Division in Nueva Ecija [Division of Science City of Muñoz (blue), Division of Cabanatuan City (red), Division of Gapan City (light blue), Division of San Jose City (orange), and Division of Nueva Ecija (composing of Palayan City and 27 municipalities colored in lavender)]	63
10	A map of Nueva Ecija showing the geographical distribution of senior high school offering STEM strand in the province as of SY 2020-2021	67
11	Schematic diagram of the methodology of the study	75
12	Sample comment of a validator for the aide memoire	84
13	Sample field notes wherein researcher's ideas were placed on a box to separate from the interviewees' insight of STEM Strand	91



Philippine Normal University

National Center for Teacher Education

14	Sample contact summary sheet	93
15	Sample Memo	96
16	Constant comparison method and coding processes in the study	97
17	Sample coded interview transcript	99
18	Sample Contact Summary Sheet for Coding	100
19	Part of matrix of participants' answers for each question	103
20	The initial diagramming constructed in the study	104
21	Overall methods conducted in the analysis phase of the study	108
22	The first validation instrument for the developed framework	110
23	The schematics of the developed framework validation using Delphi technique	112
24	Process of deriving themes with its aspect and dimensions	139
25	Qualification of the teachers in STEM Strand sourced from the participants	141
26	The six teacher's competencies as perceived by the participants	146
27	The Pedagogical Characters of the STEM Teachers	165
28	Descriptions of the interviewees on the present STEM curriculum	177
29	The subjects that still needed to be integrated as perceived by the participants	191
30	The illustration of how participants see a transformative STEM leader	208



Philippine Normal University

National Center for Teacher Education

31	Model for a Transformative STEM Leader	209
32	The skills of the learners that are developed and improved by STEM teachers to produce a holistically developed student	212
33	The totality of safe learning space	232
34	Concerns of the interviewed teachers and administrators on policies	233
35	The triad of support as expressed by the participants	252
36	The researchers' sketching and diagramming at the initial interview	276
37	The sketch of the grounded theory at the 13 th interview	276
38	The sketch of the selective codes at the end of all interviews and before the refinement of codes	277
39	The emergent STEAM Education Framework	278
40	The validated STEAM Education Framework	294
41	Quigley et al. (2020) STEAM Conceptual model	308
42	Lin and Tsai (2021) STEAM Education Framework	310
43	Kim (2016) Wheel Framework of STEAM Education	311
44	Future endeavors for the validated framework	356



Philippine Normal University
National Center for Teacher Education

LIST OF APPENDICES

APPENDIX	TITLE	PAGE NUMBER
A	List of Senior High Schools offering STEM Strand in Nueva Ecija	418
B	Geographical Distribution of SHS offering STEM Strand in Nueva Ecija	422
C	Ethical Clearance from the PNU Research Ethics Committee	423
D	Letter-Request for the DepEd Region III Approval to conduct Study in Nueva Ecija	424
E	Letter Reply of DepEd Region III regarding Approval to Conduct Study in Nueva Ecija	425
F	DepEd Region 3 Memorandum No. 228 s. 2020 (<i>Policy Guidelines on the adherence to Ethical Research Principles and Responsibilities in Studies involving Teaching, Teaching-Related, Non-Teaching Personnel and Learners</i>)	426
G	Endorsement from the Philippine Normal University	429
H	Approval of DepEd Region III Office on the Conduct of the Study in Nueva Ecija	430
I	Sample Letter to School Principal	438
J	Sample Approved Letter to HEI President	439
K	Sample Letter-Request to a STEM Teacher-Participant	440
L	Sample Letter-Request to a STEM Administrator-Participant	441
M	Informed Consent Form (<i>adapted from Alma College, Michigan, USA</i>)	442
N	Interview Guide/Aide Memoire Validators and Language	445



Philippine Normal University

National Center for Teacher Education

Editor's Profile

O	Sample Letter – Request to Interview Guide/Aide Memoire Validators	447
P	Validation Instrument for Interview Guides/Aide Memoires	448
Q	Comments of Validators on the Interview Guides/Aide Memoires	450
R	Aide Memoire for STEM Teachers	454
S	Aide Memoire for STEM Strand Administrators	457
T	Informed Consent Form for Audio- or Video-recording and Transcription (<i>adapted from Kean University, New Jersey</i>)	460
U	Sample Field Notes	461
V	Contact Summary Sheet	465
W	The Dedicated Notebook for Memoing of the Researcher	467
X	Sample Memos according to Category	468
Y	Sample Transcribed and Translated Interview	470
Z	Information Validation Form for Transcribed and Translated Interview	492
AA	Sample Initial Manual Coding	493
AB	Contact Summary Form (For Constant Comparison Method)	511
AC	List of Open, Axial, and Selective Codes derived from the Interviews	515
AD	Profile of Validators for Framework, Training Design, and Set of Indicators and Standards	524
AE	Sample Letter – Request to the Validators for Framework,	526



Philippine Normal University

National Center for Teacher Education

	Training Design, and Set of Indicators and Standards	
AF	The Front Matter and Table of Contents of the Proposed Framework given to the Validators	527
AG	The Questionnaire for the First Round of Delphi Technique for the Validation of Proposed Framework	530
AH	The Survey Questionnaire for the Second Round of Delphi Technique for the Validation of Proposed Framework	531
AI	The Resultant Framework from the First Round of Delphi Technique	534
AJ	Summary of Validators' Suggestions and Comments for the Developed Framework and the Researcher's Action	535
AK	The Questionnaire for the First Round of Delphi Technique for the Validation of Training Design and Set of Indicators and Standards	540
AL	Summary of Validators' Suggestions and Comments for the Training Design and Set of Indicators and Standards	541
AM	The Survey Questionnaire for the Second Round of Delphi Technique for the Validation of Training Design and Set of Indicators and Standards	549
AN	Constructs and Needs emanated from the interview responses	552



Philippine Normal University
National Center for Teacher Education

CHAPTER 1

THE PROBLEM AND LITERATURE REVIEW

Background of the Study

The current scientific and technological breakthroughs have resulted in tremendous advancement not only in the economic market that propels global development, but also in the larger frame of humanity. At the lead now is the fourth industrial revolution (IR 4.0) or Industry 4.0, transforming and leading the industry towards digitization, automation, and cyber-physical systems. Technological advancement has driven us to move swiftly at an unprecedented rate in which the needed qualities of the workforce in the industry have to catch up. Intelligent production, high process digitization, and organizational connectivity are the dimensions required to be understood by the workforce in dealing with Industry 4.0 (Gorecky, Schmitt, & Loskyll, 2014). In response to these needs, the education system must also evolve to join the bandwagon of Education 4.0 to attain its vision. The unprecedented changes brought about by technological innovations in this new era prompted different countries to strengthen their educational policies and systems towards Education 4.0 to produce a workforce that will suit the qualifications needed in the future job market as dictated by Industry 4.0. This new education paradigm aims to address essential skills, also known as 21st Century skills and Future skills. The 21st Century skills such as personal and social responsibility; creativity and innovation; learning to learn and metacognition; life and career; collaboration; ICT literacy; communication; citizenship; information literacy; and



Philippine Normal University National Center for Teacher Education

problem-solving, critical thinking, and decision making (Binkley et al., 2012), as well as, Future skills such as object-related, subject development-related, and organization-related skills (Ehlers, 2020) are being developed in learners to attune them to the skills that matter today, and in the future. Correspondingly, teachers have to teach their learners the necessary skills to cope with the challenges brought by Industry 4.0 on having the needed qualities as the country's future workforce. In reality however, teachers and learners are simultaneously trying to learn these skills since teachers of this generation are also non-natives of Education 4.0 and Industry 4.0. To do such, the approach in education has to meet the demands and bridge the gap that could hamper the projected success. In other countries, they invested in the so-called Science, Technology, Engineering, and Mathematics Education approach or STEM education to fill this gap.

STEM Education is one of the educational approaches that has just emerged in the field. The call for this approach began in early 2000 but is believed to have started as early as the 1950s elsewhere in the globe when the advancement of space programs began. The cold war between the United States and Russia on their ambition to bring the first man into space led to this new educational approach. The need for integration in different subjects to create and appreciate ideas and innovations has been given importance. Many first-world countries believe that STEM Education plays a vital role in providing a skilled workforce and bringing economic progress (Wise 2015, Oberoi 2016, Fiddis 2017 as cited in Morales et al., 2019). This paradigm is embedded in the strong call by US President Barack Obama in 2011 to prioritize the 21st Century skills needed in Industry 4.0 to be at par with other nations in terms of technological innovations, which



Philippine Normal University National Center for Teacher Education

revitalized the STEM approach (Gunn, 2018). Since then, this technology-based education has been an integral part of mathematics and science subjects in the US. In the Philippines, Padolina (2014) claimed that to have a highly skilled and highly productive workforce, we should have STEM Education for elementary and high school students. The STEM Education for elementary and high school students hopes to improve science and engineering education at the tertiary level and produce competent graduate programs in this field. Furthermore, this education approach may help improve the STEM pipeline, which is vital in meeting the demands of the science and technology sector of the country.

STEM education is an approach that integrates the disciplines of math, engineering, science, and technology (Akgunduz, 2016). It involves the blending of engineering and technology with the topics in math and science (Akgunduz et al., 2015). As cited in Sarac (2018), “Guzey, Harwell, and Moore (2014) contend that the aim of STEM education is to achieve an approach that focuses on the integration of learning by establishing a relationship between the disciplines, rather than being separate from each other” (p. 125). Additionally, Sarican and Akgunduz (2018) argued that STEM Education “highlights the skills in the 21st century through the four disciplines, enabling students to obtain the abilities to adapt social skills, communication skills, scientific thinking, self-control, creativeness, and innovation” (p. 94).

However, an achievement gap in STEM fields was recognized by many educators in many countries particularly in the US. This gap that other educators term as “creativity crisis” resulted from the disciplinary focus of STEM Schools in the STEM fields has



Philippine Normal University National Center for Teacher Education

been recorded in a few literatures. Zhao (2012) noted that students in STEM school recorded an increase in IQ scores, but reports also revealed the decrease of the students' creativity scores. It is in this perspective that some educators argued that design and creativity must be involved in the STEM approach, the reason why they promoted the integration of Arts in the field, thus, the birth of STEAM Education (Catterall, 2017; Eger, 2013; Kamienski & Radziwill, 2018; Long II & Davis, 2017). In the Philippine higher learning, STEAM is contextualized to the needs of the country by integrating Agriculture and Fisheries in the STEM Education; thus, STEAM initially stands for Science, Technology, Engineering, Agriculture-Fisheries, and Mathematics (CHED, 2015). Yet, Philippine educators also acknowledged the importance of arts and humanities in this field (Morales, 2017). They contend that arts and humanities, including fine arts, music, languages, and many others, are vital mechanisms to innovation. Now, the STEAM discipline in the country strengthened the relation of STEM to the Agri-fisheries and the Arts Field (Deocaris, 2018 as cited in Morales et al., 2019). In this light, the term, STE[Arts]M, was conceptualized to differentiate STEAM Education where A is agriculture or agri-fisheries. Meanwhile, Henriksen (2017) noted that seeing STEAM as mere integration of Arts and Agri-fishery fields to STEM discipline is challenging as some science teachers lack training while others could not appreciate the integration of arts. To solve this issue, design thinking as a framework may help science teachers generate creative and interdisciplinary pedagogies as a support system in their STEAM teaching.



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In 2013, educational reform was given impetus in the country. Republic Act (RA) 10533, also known as the “Enhanced Basic Education Act of 2013,” mandates the Department of Education (DepEd) with a senior high school program, an additional two years at the high school level. The republic act ensures that “the curriculum shall use pedagogical approaches that are constructivist, inquiry-based, reflective, collaborative and integrative” (Section 5e). As per the mandate, science teachers must use different strategies in teaching science to their students. Yet, the current teaching strategies employed by science teachers seemed to have not prepared the Filipino learners to large scale assessment such as PISA (Programme for International Student Assessment) that resulted to a very low rating in its 2018 assessment of reading, science and mathematics for the Philippines (San Juan, 2019; Punongbayan, 2019). The unpromising performance of Filipino learners in PISA clearly suggests that a new educational approach such as STE[Arts]M education may be needed to improve our results in the future PISA and other large-scale assessments. However, STE[Arts]M Education as an approach has not yet gained much patronage and prestige in the Philippine basic education system and even in higher learning. Limited training or capacity building in this approach has been provided to science teachers, especially at the high school level. Consequently, studies on STE[Arts]M education in the Philippines are limited, providing very little knowledge and information on STE[Arts]M to inform policies and frameworks. Thus, implementing STE[Arts]M education appears to be challenging.

To achieve the quality STE[Arts]M education we need, a framework for implementation must first be established. Literature shows that there are many challenges



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and barriers in implementing STE[Arts]M education. These challenges include the operational definition of STE[Arts]M, teachers' viewpoint on STE[Arts]M education, and teachers' dilemma towards arts integration. Add to these concerns, teachers' pedagogical and instructional practices towards STE[Arts]M education, STE[Arts]M implementation decision making, teachers' content knowledge and experience in each STE[Arts]M discipline, and teachers' limited knowledge of applying content knowledge to real-world situations also contribute to these factors (Moon, 2020). In addition, administrators also raised concerns about the lack of STE[Arts]M professional development training for them. They were worried that the development programs mostly are for teachers, hence their contribution and management towards STE[Arts]M Education were affected (Lochmiller, 2016). Such difficulties may be addressed by a carefully crafted framework for STE[Arts]M education grounded on the context of the end-users.

Implementing STE[Arts]M education without a concrete framework may only result in a messy curriculum leading to the country's unorganized delivery and management of STE[Arts]M education. Unprepared and random STE[Arts]M education implementation will only inhibit the effective inculcation of this approach for the intended schools and will only dump a load of information that will impede learning. This means that a quality framework will ensure that the implementation of STE[Arts]M education will be prepared, organized, and systematic. There are few STE[Arts]M models that have been established in other countries, but the implementation of such may not suit the contextual and cultural uniqueness of different countries.



Philippine Normal University National Center for Teacher Education

Thus, the study aimed to develop a STE[Arts]M Education framework for senior high school STEM Strand. For a pilot set-up, the study was conducted in Nueva Ecija and the framework was grounded on the context of STEM teachers and administrators in the province. The presence of this framework may help the Department of Education implement an effective STE[Arts]M education curriculum. The training design that was sourced from the framework may aid training implementers to ensure the future success of STE[Arts]M capacity building for SHS science teachers. Indirectly, the study might help senior high school science teachers to unravel a new approach that could enhance and engage their science teaching by acquiring skills and knowledge on STE[Arts]M education. The science teachers' instructional practices incorporated in the STE[Arts]M education are intended not just to boost learners' knowledge but also to develop students' competencies as the country's future workforce. From such, STE[Arts]M learning may be more relevant and evocative than the 21st Century skills and Future skills of the learners will be honed vigorously and productively to support Industry 4.0.

Moreover, the developed training design as well as the framework aimed to contribute by assuring the professional growth of the teachers through effective training on STE[Arts]M Education which may contribute to the enhancement of policies and serve as a basis for STE[Arts]M instruction. The standards and indicators generated from the framework also aimed to serve as a future quality assurance mechanism for the STE[Arts]M curriculum in the country. Hence, the findings from this study may serve as a baseline for policy making and for larger purposes of providing knowledge to teachers and delivery of learning to students. The expected output hopes to improve STE[Arts]M



Philippine Normal University National Center for Teacher Education

literacy and instruction in senior high school aligned with higher education goals in promoting scientific and technological innovations and advancement for the betterment of society and humanity. From this point forward, STEAM Education mentioned in the study refers to STE[Arts]M which is the blending of Arts with the STEM Field.

Literature Review

Quality Science Education

Science education has been defined as the teaching, learning, practices and outcomes of science. Beach (2011) defined science education as “a double term that refers firstly to systematic efforts to develop an individual’s or group’s knowledge or skills (education); and systematic knowledge about this process (science)” (p. 207). To fully understand science education, one must know its fundamental elements. Osborne (2007), through his studies, argued that,

“Science education consists of four elements: the conceptual which builds students understanding of the knowledge and ideas of science; the cognitive which attempts to develop students’ ability to reason critically in a scientific manner; ‘ideas-about-science’ which is an attempt to develop students’ understanding of both the epistemic – how we know what we know – and the processes, values and implications of scientific knowledge; and the social and affective which attempts to develop students ability to work collaboratively and to offer an engaging and stimulating experience.”(p. 177)

The purposes of science education are anchored on these elements. The US National Science Teachers Association (NSTA), the largest association of science



Philippine Normal University National Center for Teacher Education

teachers in the world, contends that the four purposes of science education are “preparing students for a career using science (pre-professional training); equipping students with practical knowledge of how things work (utilitarian purpose); building students’ science literacy to enable informed participation in science-related debates and issues (democratic/citizenship purpose); and developing students’ skills in scientific thinking and their knowledge of science as part of their intellectual enculturation (cultural/intellectual purpose)” (NSTA, 2009). Gluckman (2011) stated that quality science education could be achieved when different learning institutions attain these purposes.

Quality science education has been directly correlated with scientific literacy. Improved science literacy for some educators means quality science education in the country. Thus, others define the primary goal of science education as “building a scientifically literate society” (Glaze, 2018, p. 1). Many countries correlate quality science education to the results of international large scale assessments such as Trends in International Mathematics and Science Study (TIMSS), Programme for International Student Assessment (PISA), and Relevance of Science Education (ROSE) (Daus, Nilsen & Braeken, 2018; Neumann, Kauertz, & Fischer, 2012). Moreover, quality science education is also associated with the number of scientists or graduates in the science and engineering fields of the country. To achieve quality science education, educators focus on the different factors affecting science education, including policy, processes of science education, contextual factors, availability of resources, and the people who are either beneficiaries or benefactors of science education (Akinbobola & Ikitde, 2008).



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The need for quality science education has become more pronounced than before due to industrial globalization, internationalization, technology explosion (Turiman, Omar, Daud, & Osman, 2012), and lately, the pandemic caused by natural factors such as COVID19. The general development of a country has been directly associated with the quality of science education that a country could give to its citizens (Kalolo, 2015; Kola, 2013). Many believe that political, economic, technological, environmental, and sociocultural development is influenced and shaped by science (Heras & Ruiz-Mallen, 2017; Osborne & Dillon, 2008). It is in this context that the main goal of quality science education is anchored. It includes providing the students with the knowledge they will use throughout their lifetime and preparing them to contribute to global economic development. Hence, quality science education is imperative in the realization of sustainable national development. Achieving quality science education has been one of the major concerns of many educators. Even UNESCO acknowledged this concern through its Sustainable Development Goal No. 4 wherein quality education must be prioritized for a country's sustainable growth and development.

Kwok (2018) argued that to have quality science education, an integrated approach in teaching science must be realized to prepare the students for diverse future careers. He posited that learning institutions “should develop students as people, prepare them to think and set the foundation for life-long self-learning and self-improvement.” (p. 533). Also, he contends that the key factors affecting science education development and quality are science teachers since some are not professionally qualified. In their defense, teachers pointed the blame to the government for providing limited resources in science



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education. In response, more and more authorities are now taking measures to wit: “implementing curricular reforms; creating partnerships between schools and companies, scientists and research centers; cooperating with universities to improve initial teacher education; and initializing projects focusing on continuing professional development” (Eurydice Network, 2011, pp. 26-27).

In addition, some educators claim that the key problem in achieving quality science education is that elementary, high school or even college learners do not see the applications of science in their lives. They tend to see science as irrelevant and abstract ideas. This phenomenon is more evident among secondary level students, sounding more alarm since this is the period where students contemplate their career choices. High school years are believed to be the most problematic years in teaching science since many students are disengaged and disconnected in science during and after this level (Aikenhead, 2001; Aikenhead, 2006; Harris, Jensz, & Baldwin, 2005; Sjøberg & Schreiner, 2005; Stocklmayer, Rennie & Gilbert, 2010).

In this perspective, science education has to be reoriented within or in terms of the pedagogical aspect by teaching science as an art of obtaining scientific knowledge rather than as a highly technical subject dealing with the methods of classifying, observing, and knowing the environment and fundamentals of life processes and functions (McFarlane, 2013). This reorientation is wanting since new sets of skills known as 21st Century Skills and Future Skills emerged with the advent of IR4.0.



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Science Teaching, 21st Century Skills, and Future Skills

With the advancement of science and technology, education also evolves with the needs of the 21st century, which is known as “the century of knowledge and innovation-based economy (Liliana & Florina, 2015; Turiman, Omar, Daud, & Osman, 2012). This century requires high-level skills in employment; thus, the understanding of science and other necessary skills such as 21st Century Skills and Future Skills is very essential (Suwono, 2016). Within the same timeframe, IR 4.0 has found its place and the need for the workforce with automation and digitization skills are becoming vital.

The 21st Century skills matter in the new era. From a local to a global context, 21st Century skills have developed and evolved into complicated tasks (Ait, Rannikmäe, Soobard, Reiska, & Holbrook, 2015; Schleicher, 2018). These skills such as personal and social responsibility skills, creativity and innovation skills, learning to learn and metacognition skills, life and career skills, collaboration skills, ICT literacy skills, information literacy skills, communication skills, citizenship skills, problem-solving, critical thinking skills, and decision-making skills (Binkley et al., 2012) are focused and honed by educators through quality science teaching. To clearly understand 21st Century skills, some educators categorized them into three: life, learning, and literacy skills, known as the 3Ls of 21st Century skills (Zook, 2019). Life skills pertain to a person's competencies on how his/her own life delves into his/her profession. Life skills include flexibility, initiative, productivity, social skills, and leadership.



Philippine Normal University National Center for Teacher Education

Meanwhile, learning skills are the skills related to the mental processes needed in this era. The learning skills include the 4Cs of 21st Century skills namely creativity, critical thinking, communication, and collaboration. Fundamentally, literacy skills pertain to the ability of processing facts, digital technology, computation, among many others. Literacy skills include information literacy, media literacy, and technological literacy.

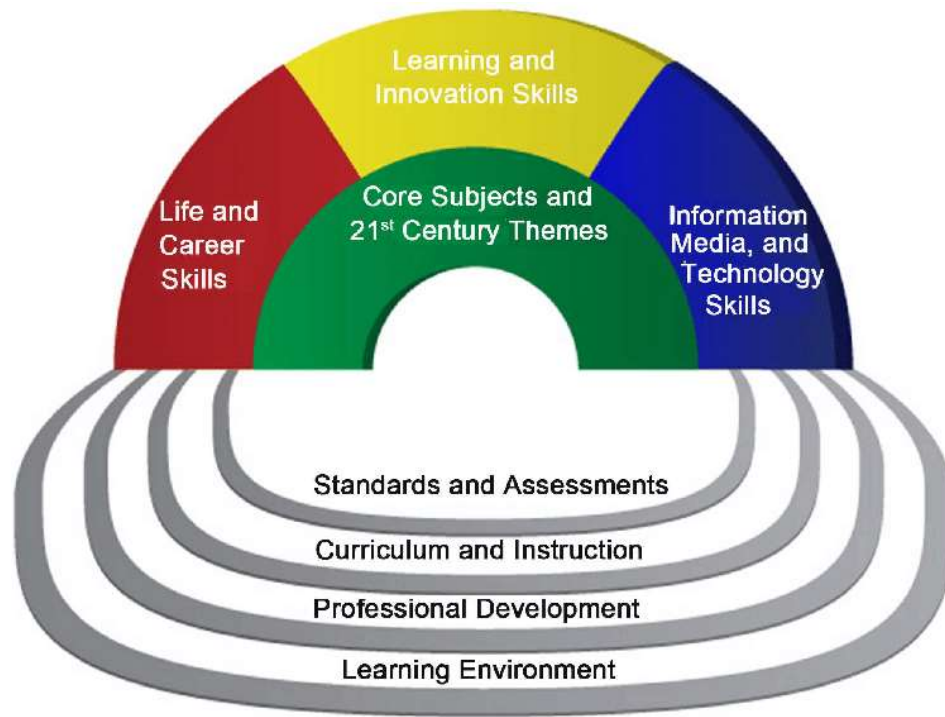


Figure 1. *Partnership for 21st Century Learning (P21) Framework for 21st Century Learning (Figure from www.battelleforkids.org/network/p21)*

According to Partnership for 21st Century Learning also known as P21, the 3Ls of 21st Century skills require an “innovative support system to engage learners through applicable skills and knowledge, appropriate technologies, and real-world connections to



make learning relevant, personalized, and engaging” (P21, 2019, p.2). These support systems include learning environment, curriculum and instruction, standards and assessment, and professional development that are 21st century-based (Figure 1).

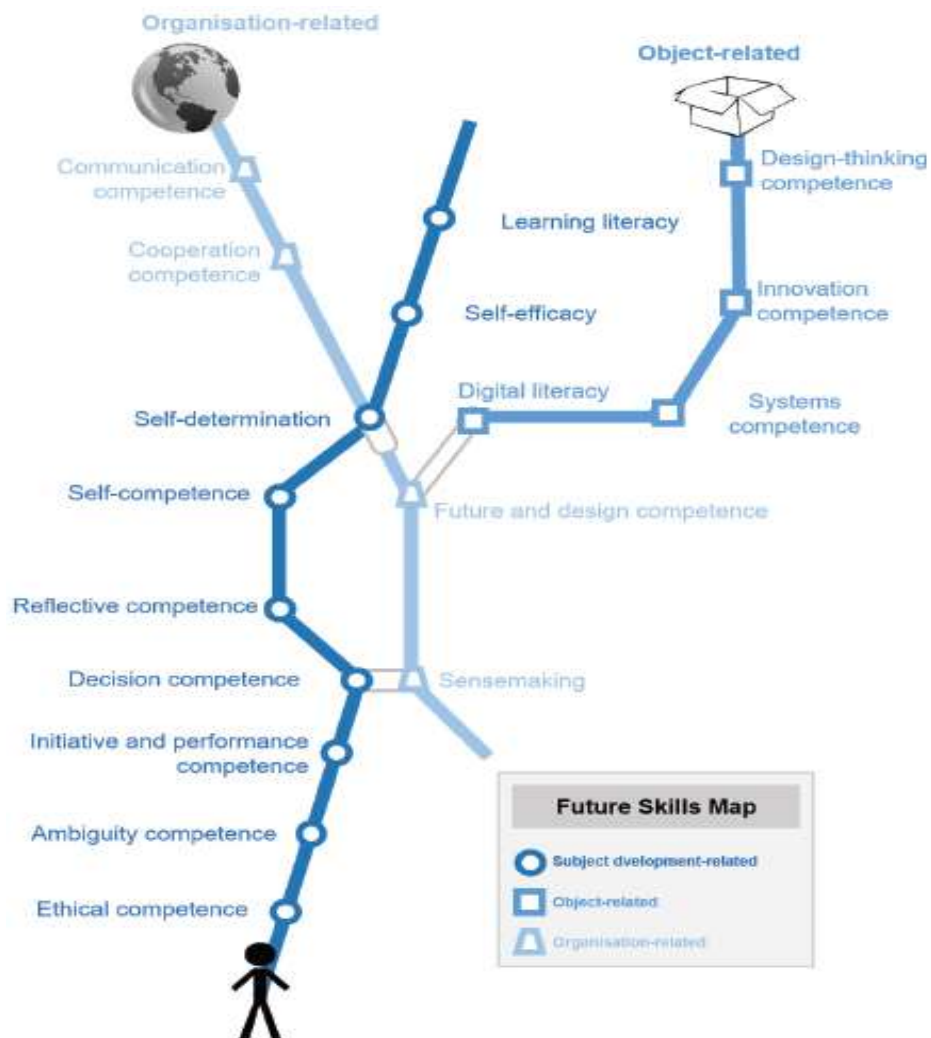


Figure 2. *Map of Future Skills (Ehlers, 2020)*



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On the other hand, Future Skills refers to an individual's ability to evolve and adapt so that he or she can productively engage in the work - environment and “life of tomorrow”, actively influence it, and organize himself or herself to deal efficiently with future issues (Ehlers, 2020). Future skills are sets of skills connected and related to 21st Century skills, but are more specific to educational sectors. These skills are generally used and needed in teacher professional development programs, basic and higher education institutions, and specific content disciplines or domains such as the STEM Field (Ehlers, 2020; Wagennar, 2010).

Future skills are divided into three competence clusters: organization-related competences, object-related competences, and subject development-related competencies (Figure 2). The organization-related competence cluster is concerned with the institutional, organizational, and social settings, which consist of four competencies: sensemaking, future and design competence, cooperation competence, and communication competence. Thus, these skills include the ability to create meaning and value, the ability to design and build the future, the ability to collaborate with others, and the ability to criticize and communicate (Ehlers & Kellermann, 2019). Meanwhile, object-related competence clusters composing digital literacy, systems competence, innovation competence, and design-thinking competence deals with the ability to operate analytically, creatively, and with a heightened state of comprehension regarding specific tasks, topics, and objects. These competencies are primarily concerned with handling circumstances under unknown conditions in the most innovative and creative ways (Meyer – Guckel et al., 2019). Lastly, the subject-development competence cluster



Philippine Normal University National Center for Teacher Education

encompasses dispositions and abilities dealing with self-reflection, self-confidence, learning and development capabilities, values, convictions, differentiation, and distinction. From this definition, this cluster of competence contains nine future skills to wit: ethical competence, ambiguity competence, initiative and performance competence, decision competence, reflective competence, self-competence, self-determination, self-efficacy, and learning efficiency (Ehlers, 2020).

There is no doubt that there is a strong connection between science education and 21st Century skills and Future skills since these skills cannot be realized without quality science education. Through quality science education, 21st Century skills and Future skills may be developed and advanced along with the scientific processes that can be integrated with the skills, achieving skilled and science-inclined individuals (NSTA, 2011).

In developed countries and other developing countries, new and sophisticated approaches emerged to promote scientific literacy in relation to 21st Century skills and Future skills and achieve quality science education. This approach, known as STEM Education, was made by integrating subjects into science with an emphasis on technology.

STEM/STEAM Education

STEM Education

STEM Education has been defined as the integration of the disciplines of mathematics, technology, science and engineering. It was initially called SMET



Philippine Normal University National Center for Teacher Education

Education by the US National Science Foundation (NSF) in the early 1990s (Catterall, 2017; Sanders, 2009; White, 2014) but was changed to STEM Education in 2011 as popularized by then NSF Director Judith Ramaley (Breiner, Johnson, Harkness, & Koehler, 2012). It is different from the STEM field that denotes the separate disciplines (science, technology, engineering, and mathematics) whereas STEM Education is integrative in which the content of science and mathematics are blended with the technology and engineering (Akgunduz et al., 2015). The difference was explained by Ostler (2012) in which “a degree in a STEM discipline would have the option to be highly specialized while a STEM education degree will require a somewhat broader general understanding of the interrelatedness of STEM topics.” (p. 29).

STEM Education is believed to have started after Sputnik 1 was launched in 1957. This giant leap for the former Soviet Union was considered a failure for the United States since this was when the “intellectual war” or cold war for the two giants was imminent (Burrows, Lockwood, Borowczak, Janak, & Barber, 2018). This failure for the space race propelled the USA to advance its technological innovations. The goal of improving science and engineering so that the USA can improve its space presence led to the creation of the US National Aeronautics and Space Administration (NASA) on July 29, 1958 (White, 2014). Since then, NASA has paved the way for many STEM Education inventions and creations. The initiatives led the USA to be at the forefront of STEM Education. Initially, the goals of STEM Education in the US are “to increase advanced training and careers in STEM fields, to expand the STEM-capable workforce, and to



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increase scientific literacy among the general public” (National Research Council, 2011, p.4).

STEM Education is a technology-based education that has interdisciplinary and multidisciplinary approaches, thus, it helps students to have a deep conceptual understanding of the STEM subject and that may develop 21st Century skills and Future skills. The cutting edge of STEM Education with the other approaches is its interdisciplinarity since “real-world problems are not fragmented in isolated disciplines as they are taught in schools and to solve these problems, people need skills that cut across the disciplines” (Thibaut et al., 2018, p. 2). In this perspective, STEM Education is considered to be helpful in achieving quality science education (El-Deghaidy & Mansour, 2015; Kuenzi, 2008; Sarac, 2018). However, the deep conceptual understanding will only be attained if the teacher has mastery of STEM content and has the experience of an integrated advanced pedagogical approach (Ostler, 2012).

STEM Education is a new trend not only in developed countries but also in developing countries (UNESCO, 2010; van der Vleuten, Steinmetz, & van de Werfhorst, 2018; Xie, Fang, & Shauman, 2015). This approach is considered as a priority for high-, upper-middle-, lower-middle, and low-income countries (Ostler, 2012) since studies revealed that STEM education is essential to “facilitate economic development, international competitiveness, and job creation” (Ismail, 2018, p. 2). England, Korea, Turkey, Saudi Arabia, Australia, Africa, among other countries, accepted and implemented STEM Education in their curriculum since many studies suggest that it “allows students to collaborate, communicate, think critically and creatively (4Cs);



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promotes lifelong learning skills especially 21st Century Learning Skills; gives the opportunity to the students to gain the skills in four fields at the same time; and creates an environment to teach engineering, science, technology and mathematics” (Turk, Kalayci, & Yamak, 2018, p. 1287). In addition, STEM education advocates believed that students would be more equipped as future STEM workforce due to the “enhanced mathematics and science skills gained through the application of authentic technology and engineering design” (Carter, 2013, p.6). Further, Carter (2013) contends that,

“Student preparation in STEM education that involves problem-solving through design and the ability to think critically across disciplinary boundaries is fundamental in supporting the ever-increasing mandate for a STEM workforce capable of adapting to and innovating in the 21st century” (p. 6).

There is still a lot of misunderstanding about STEM education and how it should be done. STEM education is frequently used to indicate something new and exciting, however it may really consist of unrelated disciplines. STEM Education has grown into a meta-discipline, an integrated endeavor that focuses on creativity and the applied process of developing solutions to complicated contextual issues utilizing contemporary tools and technology, rather than conventional barriers between different courses (Kelly & Knowles, 2016). STEM education may connect scientific inquiry to engineering design by generating questions that can be addressed through investigation to inform students before they begin the engineering design process to solve issues (Kennedy et al. 2014). STEM education has concentrated on strengthening science and mathematics as separate subjects throughout the previous few decades, with little integration or attention paid to



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technology or engineering. Sanders (2009) defined integrated STEM education as approaches that investigate teaching and learning between and among any two or more STEM subject areas, as well as between a STEM topic and one or more other school subjects. Sanders proposes that at least one of the other STEM topics' learning objectives be purposefully included into a discipline—for example, a math or science learning result in a technology or engineering class. Thus, integrated STEM education is an endeavor to incorporate any or all of the four disciplines of science, technology, engineering, and mathematics into a single class, unit, or lesson based on links between the fields and real-world situations.

STEM content learning objectives can be largely centered on one topic in integrated STEM curriculum models, but contexts can derive from other STEM courses. Based on disciplinarity, STEM education can be described as a method of teaching the STEM content of two or more STEM domains in an actual environment, constrained by STEM practices, with the goal of linking these disciplines to improve student learning.

Sarican and Akgunduz (2018) found that the STEM approach positively contributed to the students' academic achievement. Soules and colleagues (2014) argued that through STEM Education and by embedding proper teaching methods, learning would improve and promote multiliteracies in classrooms. Studies also suggest that the integration of subjects in STEM Education increased the motivation and achievement of the students and the number of students who are taking STEM-related courses in higher education also increased (Becker & Park, 2011; Honey, Pearson, & Schweingruber, 2014; National Academy of Engineering and National Research Council, 2014; Vennix,



Philippine Normal University National Center for Teacher Education

den Brok, & Taconis, 2018). In fact, Yildirim (2016) meta-analysis review of 34 studies about STEM Education showed that the approach generally positively improves students' scientific knowledge, interests, and motivation. Also, the review discussed the development of students' problem solving and creative skills and students' scientific attitudes and processes using STEM education. Furthermore, it has revealed that STEM education directly correlates with the results and rankings on TIMSS and PISA.

However, many studies revealed the lack of teachers' pedagogical knowledge and self-efficacy toward STEM Education (Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013; Nadelson & Seifert, 2017; Stohlman, Moore, & Roehrig, 2012). This challenge must be addressed since STEM education classrooms compel the science teachers to be multimodal in their teaching methods to fully achieve the goal of STEM education, and the lack of pedagogical knowledge will greatly affect this multimodality. This is also in accordance with the study of Pasnik and Hupert (2016) in the United States that "they [teachers] lack an adequate grounding on relevant STEM knowledge, and in pedagogical strategies that support the learning of that knowledge, they lack access to professional development opportunities in STEM, and they lack access to high-quality resources that can help all students achieve standards-based STEM learning outcomes in a rapidly changing educational landscape" (p. 5). This problem seems to be felt worldwide as the same findings were found in Saudi Arabia (El-Deghaidy, Mansour, Alzaghibi, & Alhammad, 2017), in Korea (Lee et al., 2012), in Australia (Marginson, Tytler, Freeman, & Roberts, 2013), in Africa (Tikly, Joubert, Barrett, Bainton, Cameron, & Doyle, 2018) and in Malaysia (Hoe Ng & Adnan, 2018) where teachers complain



Philippine Normal University National Center for Teacher Education

about insufficient time, lack of school administrators' support, lack of expertise, and shortage of available instructional and learning materials for STEM Education. More alarming is that teachers stick mostly to their traditional beliefs about teaching and learning that they resist new approaches like that of STEM Education (Ashgar, Ellington, Rice, Johnson, & Prime, 2012).

In terms of research, the five major research fields where the STEM approach is incorporated are education, psychology, engineering, healthcare science services, and computer science (Yu, Chang, & Yu, 2016). Noteworthy is the importance of STEM Education in psychology which concretizes the importance of STEM Education in students' learning. Learning experiences of teacher and student, pedagogical content, future classroom environment, and innovation of learning and teaching activities with ICT support are the current research areas for STEM Education (Polgampala, Shen, & Huang, 2017). However, a new discipline was being integrated into STEM Education which many educators now advocate. This arts integration to STEM Education is now known as STEAM Education.

STEAM Education

The birth of STEAM Education started when the need for design and creativity was realized in consonance with STEM (Catterall, 2017; Hunter-Doniger, 2019; Zhang & Zhang, 2016). Georgette Yakman is believed to be the main proponent who coined the term STEAM Education in 2006 during her graduate studies at the Integrated Science-Technology-Engineering-Mathematics Education program (ISTEMed) of USA Virginia



Polytechnic and State University (Bahrum, Wahid, & Ibrahim, 2017; Li, Gao, Zou, & Wan, 2016; Wang, Xu, & Guo, 2018). STEAM stands for Science, Technology, Engineering, Arts, and Mathematics. Yakman (2015) described STEAM as “science and technology interpreted through engineering and the arts, all based in mathematical elements” (see Figure 3). Arts disciplines such as painting, music, theatre, dance, among many others, have been shown to improve students’ learning, attention, and cognition (Posner & Patoine, 2010; Zhbanova, 2017).

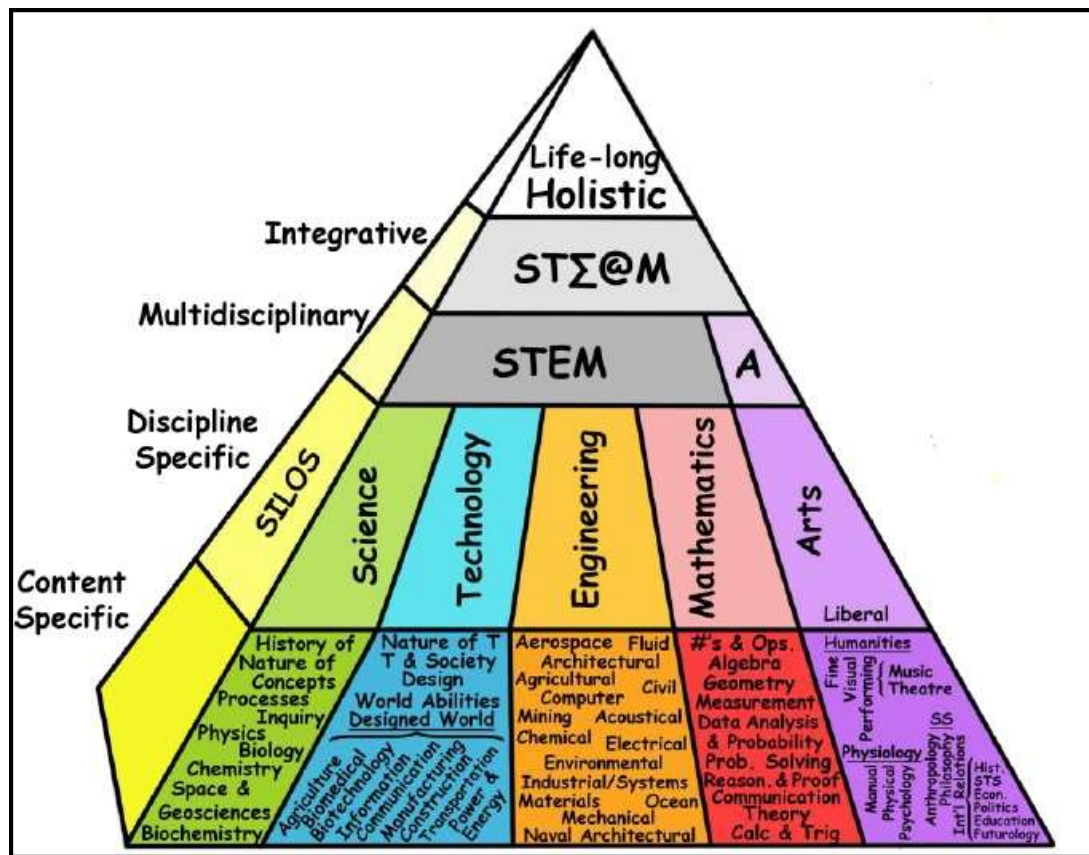


Figure 3. Yakman (2010, 2015) Framework for STEAM Education



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The integration of Arts in STEM promotes more creativity, interdisciplinarity, authentic learning, and project-centered thinking (Crayton & Svihla, 2015; Dyer, 2019; Henriksen, 2014; Kim & Park, 2012; Kuhn, 2015; Rolling Jr, 2016; Yakman, 2010). The main reason is that “arts provide innovations through analogies, models, skills, structures, techniques, methods, and knowledge” (Daugherty, 2013, p. 11). Creativity is at the core of STEAM education since it is believed to be at the heart of science and art (Conradty & Bogner, 2018; Guyotte et al., 2014; Oner et al., 2016; Tsurusaki, Tzou, Carsten Conner, & Guthrie, 2017). As stated by Zimmerman (2016), “STEAM education is able to cultivate the critical, creative, and participatory dispositions necessary for authentic engagement in both science and art. STEAM curriculum and instruction afford students opportunities to exercise divergent thinking, to appreciate the complexity of digital communication, to experiment with new ways of expressing themselves, and to experience the inherent beauty of the natural world” (p. 1). An integrative literature review of 44 STEAM Education articles conducted by Perignat and Katz-Buonincontro (2019) found out that STEAM Education is defined in five ways. STEAM Education is either multi-disciplinary, transdisciplinary, arts-integration, cross-disciplinary, or interdisciplinary.

STEAM approaches are found good collaborators with conventional pedagogy and development strategy in the sciences (Connor, Karmokar, & Whittington, 2015; Segarra, Natalizio, Falkenberg, Pulford, & Holmes, 2018; Thurley, 2016). The STEAM approach allows the students to exercise innovative thinking and creativity. Thus,



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STEAM strategies are thought to foster the imagination of scientists and soon-to-be scientists. Further, studies showed an intensification of enjoyment in learning and longer learning retention (Brouillette & Graham, 2016; Rahmawati, Ridwan, Hadinugrahaningsih, & Soeprijanto, 2018). Aside from enhancing students' creativity and self-expression, STEAM education also promotes interest in the STEM field, cultivates the problem-solving skills of the students, provides a trail for self-motivation and personal meaning-making, improves convergent and divergent thinking skills, and enhances the 21st Century skills and Future skills (Land, 2013; Madden et al., 2013; Perignat & Katz-Buonincontro, 2019; Psycharis, 2018; Watthananon, 2018).

This is in line with the aims of STEAM education that Colucci-Gray, Burnard, Cooke, Davies, Gray and Trowsdale (2017) proposed such as “STEAM improves the general attainment of young people, STEAM increases innovation and STEAM motivates and engages young people into STEM subjects and careers.” This is anchored with the policy “STEAM for education, STEAM for employment, and STEAM for the economy” (CLA, 2015). Thus, STEAM Education may innovate the future since this type of approach may create diverse integrated careers like “astronautic geologists, biomimicry analysts, quantum linguists, roboticists, medical mathematicians, and crypto-privacy engineers” (Land, 2013, p. 550).

Meanwhile, Henriksen (2017) noted that seeing STEAM as mere integration of the Arts field to STEM discipline is challenging. Some science teachers are not artistic, while others could not appreciate the integration of arts in the STEM disciplines. The STEAM educational process involves “creative problem solving, critical thinking,



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communication, collaboration, critique, perseverance, and hard work” (Bazler & Van Sickle, 2017, p. 25). Thus, teachers also need to acquire these skills to incorporate the process in their teaching. To solve the dilemma, design thinking as a framework may help science teachers generate creative and interdisciplinary pedagogies to support their STEAM teaching.

STEAM education provides students with interdisciplinary experiences that can help them achieve a variety of pedagogical goals, including increased engagement, the development of creative abilities, and opportunities to explore how disciplines can be used in new ways. Yakman (2010) has tried to promote STEAM as an educational approach for integrating the conventional academic topics of science, technology, engineering, mathematics, and the arts. She proposed that integration may be accomplished in two ways: by each field incorporating components from other disciplines into its own standards and practices, or by using the STEM idea and practices when the courses are purposely combined (Yakman, 2010). In its objectives to integrate work across (inter-) and beyond (trans-) disciplines, Conner et al. (2017) claimed that STEAM must be extensively generative of innovative and creative approaches to the domains of the arts and STEM learning, particularly around new media, making, and digital technology.

It is vital to investigate the interactions that take place across the disciplines that make up STEAM in order to properly understand the boundaries within, between, and across them. Interdisciplinary interactions between two or more disciplines (Carr et al., 2018) have been conceptualized in a variety of ways: as a search for a more unified or



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connected form of knowledge that can connect different disciplines to make broader claims; as a rebuttal to the existence of disciplines and a challenge to knowledge production traditions; and as a way of transcending the limited epistemological potential of existing disciplines on their own (Moran, 2001). An interdisciplinary curriculum, for example, may be advocated in education because of its promise to help provide a more historically situated and culturally sensitive approach to teaching sciences and mathematics, or because of its potential to mold new ways to ever-stricter student evaluation regimes.

Transdisciplinary STEAM, on the other hand, is characterized as a mixing of disciplines that emphasizes the co-equal and comprehensive integration of theoretical and systematic methods (Osborne, 2015). However, there are significant contrasts between interdisciplinarity and transdisciplinarity conceptualizations. Interdisciplinarity serves as a "trading zone" between disciplines, but transdisciplinary approaches provide new ways of knowing through deeper integration of knowledge and methodologies (Galison & Stump, 1996). The STEAM program needs a deliberate relationship among assessments, lessons design or implementation, and standards. The STEAM paradigm promotes learning experiences in two or more strands through these interactions. Through inquiry and cooperation, transdisciplinary knowledge and abilities complement each other while maintaining the integrity and ethics of cohabitation and mutual respect (Romero, 2017). As a result, via transdisciplinary knowledge and conscience, STEAM is a new vision to foster student creativity, cooperation, and communal existence (Cluoko, 2020).



Philippine Normal University National Center for Teacher Education

Students can be engaged in a variety of ways thanks to these disciplinary combinations in STEAM. Students can profit from absorption with the distinctions of technology and art in the case of hard-applied sciences and pure-soft pairings. In certain circumstances, art is used to engage students in technology in order to boost the number of students pursuing STEM subjects (Carrie, 2018). In other examples, technology is used in a creative environment, demonstrating the larger significance of technology in potentially unexpected domains. Students can see similarities between hard and soft disciplines that share the pure dimension, namely the exploratory or observational characteristics of both kinds of knowledge, using soft-pure and hard-pure combinations, despite the fact that hard disciplines are concerned with universals and soft disciplines are concerned with particulars. Students find parallels between soft-applied and hard-applied disciplines, as well as another type of combination of hard and soft disciplines, with both types of merging disciplines having an applied focus, or practical use in the real world. (Williamson & Knoxville, 2018).

STEAM education, in this context, serves as a paradigm for establishing a new interface between theory and practice, breaking/crossing academic boundaries (Connor et al., 2015; Quigley et al., 2019). The arts in STEAM not only binds the disciplines together as a single organism with a greater scope and disciplinary identity, but it also encloses the basic qualities of the entire in order to replicate real-world difficulties and concerns (Quigley & Herro, 2019).

Different factors have been proven to contribute to STEAM cognitive learning of students. Thuneberg, Salmi, and Bogner (2018) found out that creativity, visual



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reasoning, and autonomy affect students' cognition in a STEAM setup. Aside from the mentioned factors, contextualization also affects the learning of the students (Jho, Hong, & Song, 2016; Radziwill, Benton, & Moellers, 2015; Yakman & Lee, 2012). Ozcan and Topsakal (2020) even found out that STEAM Education fosters good conceptual understanding and minimizes the alternative conceptions or misconceptions of the students on a topic or subject. In addition, the STEAM Education approach also improves the students' computational thinking skills (Bati et al., 2018). Also, educational programs anchored on STEAM positively affect the students' multiple intelligences (logical-mathematical, bodily-kinesthetic, spatial, linguistic, natural, intrapersonal, interpersonal, and musical) (Aljazaeri & Alchalabee, 2019). However, the gender gap is still widely experienced in STEAM Education (Jimenez Iglesias et al., 2018). Mote, Strelecki, and Johnson (2014) suggested that high-level organizational engagement such as partnerships in museums, higher education institutions, and community leads to students' new learning experiences.

Philippine STEM Workforce and STEAM Education

The STEM workforce can drive the economic growth of a country. Sadly, the Philippines lacks a STEM workforce. A plethora of STEM professionals is elsewhere in the globe. A prominent scientist/agriculturist, William Dar, noted that the Philippines has a very low number of scientist/researchers to population ratio (Jalea, 2018). The United Nations Educational, Scientific and Cultural Organization (UNESCO) recommends that there should be 380 scientists/researchers per one million population in



Philippine Normal University National Center for Teacher Education

a country, but the Philippines has only 189 scientists/researchers per million population (spmp). This is far from its neighboring countries like Singapore (6700 spmp), Thailand (974 spmp), Malaysia (2100 spmp), South Korea (6900 spmp), Vietnam (674 spmp) and Israel (8300 spmp) where there exists a significant excess on the baseline value of UNESCO recommendations. In terms of spmp, the Philippines is only on the same page with Indonesia (89 spmp) and Brunei (286 spmp). To meet the baseline value, the Philippines needs more than 19000 new scientists (Ambag, 2018). In addition, the Philippines is short of about 15000 medical doctors. The 2016 data showed that there is only one doctor for every 33000 persons in the country. This data is exceedingly low compared to Cuba where the ratio is one doctor per 1075 persons (Cabato, 2016). Furthermore, the government also showed low budget allocation for research and development (R&D). UNESCO's recommended budget for R & D is one percent of the country's Gross Domestic Product (GDP). In comparison, the Philippines' expenditure on R&D projects is only 0.14 percent of its GDP (Ambag, 2018).

The data show that the STEM workforce in the Philippine Industry is still wanting. The Philippines must invest in new pedagogical approaches such as STEM/STEAM Education to meet this need. The Philippines is a highly agricultural country; thus, STEAM Education is contextualized on the country's needs by integrating Agriculture and Fisheries in STEM Education. Initially, STEAM stands for Science, Technology, Engineering, Agriculture-Fisheries, and Mathematics (CHED, 2015). However, Philippine educators also acknowledged the importance of arts and humanities in this field (Morales, 2017). Now, the STEAM discipline in the country strengthened the



Philippine Normal University National Center for Teacher Education

relation of STEM to the Agri-fisheries and the Arts Field (Deocaris, 2018 as cited in Morales et al., 2019). Padolina (2014) believed that to have a highly skilled and highly productive workforce, STEM Education for elementary and high school students is important. The STEM Education for elementary and high school students hopes to improve science and engineering education at the tertiary level, producing competent graduate programs in this field.

As of 2018, the Commission on Higher Education (CHED) registered 1.1 million enrollees in STEM disciplines in different Higher Education Institutions (HEIs). In the said data, no gender disparity was recorded. This is in consonance with the study of Llenares and Deocaris (2014) in which gender disparity is not felt in STEM professional careers in the country. However, what is alarming albeit the high number of enrollees in STEAM courses is the low completion rate in these courses. In the five-year data of CHED from 2012-2017, results showed that the completion rate for science was 25.52%, 14.38% for medical and allied fields, 21.2% for mathematics, 19.56% for information technology, 18.97% for engineering and technology, and 26.91% for agricultural field with the grand average completion rate of a low 21.10% (Anito, Morales, & Palisoc, 2019). Some researchers put the blame on the teachers. However, the responsibility is not theirs alone since there are many indicators that STEAM Education has not yet gained much patronage and prestige in the Philippines, thus, limited research on the trends and issues of this approach in the country.

In 2017, Morales and colleagues conducted a study to generate a Philippine STEAM Education Model based on Higher Education Institution (HEI) teachers'



Philippine Normal University National Center for Teacher Education

perspectives to serve as a blueprint for a STEAM higher and advanced learning. As Morales and colleagues (2019) described the model,

“This model exemplifies innovative, appropriate, and contextualized pedagogy, assessment, and technology integration in educating the Filipino learners to become productive citizens, innovative STEAM professionals, and 21st century-skilled human resource” (p. 85).

The model as shown in Figure 4 is in a wheel-like image within the teaching and learning domains that “affords directions, pathways, and way forward in the field of STEAM education for better management of learning to develop quality STEAM human resources as outcomes, and enhances STEAM literacy to improve life management, resource management, risk reduction and help sustain the knowledge and resources to develop lifelong learning skills for quality living” (Morales et al., 2019, p. 86). In these domains namely pedagogy, assessment, and technology integration, four variables were found to be common. These variables (outcomes, drivers, institutional support, and processes) are in balance and in equality between and among them, resulting in the model's circular nature.

Furthermore, Morales and colleagues (2019) added that “it is envisioned that the model captures the exact conditions of the STEAM Teachers in HEIs, and at the same time provides and enhances the learning competencies of STEAM Educators for them to fluidly traverse the career stages (Beginner, Proficient, Highly Proficient, Distinguished) looking forward to attaining quality in Philippine STEAM Education and draft the



Generation Z learners with specialized skills (e.g. design thinking, technical know-how, and time management) to prepare these citizens to be part of Workforce 4.0” (pp. 85-86).

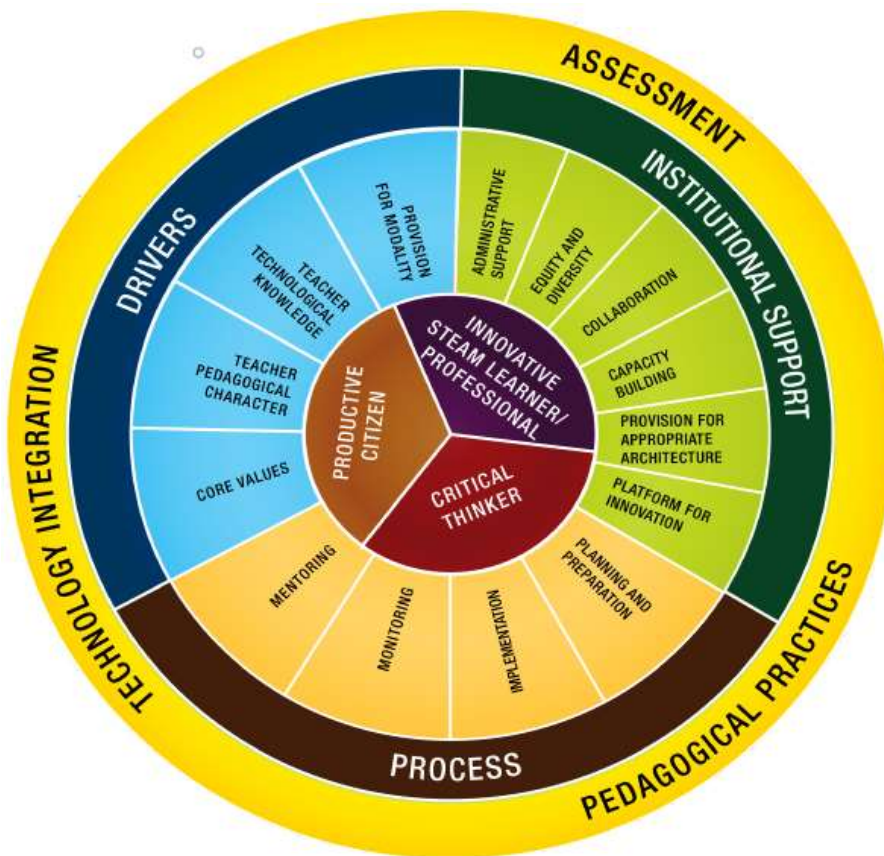


Figure 4. *The Philippine STEAM Education Model (Morales et al., 2019)*

However, this study is limited to the HEIs teachers. Research has yet to flourish for STEAM Education in basic education. This lack of research also resulted in limited knowledge about STEAM Education for the high school teachers and administrators; hence, a framework on STEAM Education becomes relevant today. Yet, implementing



Philippine Normal University National Center for Teacher Education

this approach appears to be challenging because of the barriers and challenges that loom in STEAM Education.

Challenges and Barriers in Implementing STEAM Education

As policy makers and STEAM Education advocates work for its implementation in schools, challenges and barriers have emanated or emerged during the process. These challenges and barriers have undeniably affected the teachers and have put them in the blank wall. Some of these challenges include the operational definition of STEAM, teachers' pedagogical know-how, and the dilemma of arts integration. The purpose of STEAM seems to be a challenge since some educators contend that STEAM education is either multi-disciplinary, transdisciplinary, arts-integrated, cross-disciplinary, or interdisciplinary. This is in line with an integrative literature review conducted by Perignat and Katz-Buonincontro (2019) wherein 44 articles define STEAM Education in five ways. These, all the more, make STEAM Education a confusing one.

In addition, Moon (2020) listed four known barriers in implementing STEAM education. Pedagogical and instructional practices, STEAM implementation decision making, teachers' content knowledge and experience in each STEAM discipline, and the teachers' limited knowledge on applying content knowledge to real-world situations complete this list. Not only that teachers need support in appreciating concepts in the context of real-world problems, but there is also a dire need for student-centered learning, authentic assessment, and implementing project-based learning which is vital in STEAM



Philippine Normal University National Center for Teacher Education

education implementation (Stubbs & Meyers, 2015). Such also happened in Korea where teachers perceived that “finding time to carry out STEAM lessons, increased workloads, and lack of administrative and financial support” were identified challenges in implementing STEAM Education (Park, Byun, Sim, Han, Baek, 2016, p. 1739).

Several reports claimed that teachers were being pressured to integrate STEM disciplines for STEM Education. They were overwhelmed by the addition of Arts as another subject to the needed STEAM Education (English, 2017). Science teachers are challenged to integrate the Arts field into STEM discipline as some are not artistic while others do not appreciate the integration of arts in the STEM disciplines (Henriksen, 2017). Carsten Conner, Tzou, Tsurusaki, Guthrie, Pompea, and Teal-Sullivan (2017) recognized this difference between science and arts that sometimes educators just force the two subjects to be integrated so that their teaching is aligned with STEAM Education. This occurrence also lessens the confidence of teachers towards STEAM teaching. To avoid this problem, Carsten Conner and colleagues (2017) proposed six core STEAM practices namely: “(a) leveraging science concepts to create meaningful artwork; (b) focusing on outcomes that have a personal and/or aesthetic meaning; (c) conducting open exploration in the context of both science and art; (d) designing with intention (e.g., choices around medium, technique, and composition); (e) iterating through several drafts, prototypes, or models; and (f) communicating about process and outcome” (p. 2225).

Jamil, Linder, and Stegelin (2017) reported that some teachers, mainly at the elementary level, perceive STEAM education as a task-oriented approach rather than pedagogy. Because of this viewpoint, teachers complain about the time used mostly on



Philippine Normal University National Center for Teacher Education

the activities of STEAM instruction rather than on the content. Consequently, this teacher's perspective created problems and concerns in time management, classroom behavior management, and the student's holistic development. This was supported by the study of Zimmerman (2016) that science teachers are mostly on procedural knowledge (doing laboratory-based activities) than connections on real-world situations and content knowledge. Further, teachers also complained about the lack of STEAM experiences and exposure during their pre-service training (Moon, 2020). The longitudinal study of 33 math and science teachers implementing STEAM education in their teaching conducted by Herro, Quigley, and Cian (2019) found out that the challenges they faced in this approach include time, student' understanding of the process and content, planning concerns, and issues about national and regional policies.

Lochmiller (2016) also reported that administrators' expertise in the STEM field also affects STEAM instruction. The study posited that administrators who were non-science majors tend to focus more on classroom management and general pedagogy rather than the content, which proves to be the important feedback for teachers to improve their own instruction and advance student learning outcomes. This was supported in the study of Moon (2020) wherein administrators complain about the lack of STEAM professional development training, thus they have no knowledge on how to give sustenance to their teachers regarding STEAM instruction. To add complication to this, Avramides, Hunter, Oliver, and Luckin (2014) reported that "top-down administrator-level decision" in schools also serves as a barrier to STEAM Education implementation as teachers are hesitant or less engaging for collaboration.



Philippine Normal University National Center for Teacher Education

In the Philippines, research has yet to flourish for STEAM Education in basic education. The scarcity or lack of research and literature resulted in limited knowledge about the challenges and barriers of implementing STEAM Education for high schools in the Philippine setting. With these challenges and barriers coupled with the unfamiliarity of STEAM Education, implementation of the same appears challenging. However, studies (Kang, 2019; Moon, 2020) revealed that a possible indicator for STEAM education is the current STEM Education of the country. In the Philippines, a new curriculum known as K to 12 curriculum was implemented creating the senior high school level. This additional level paved the way for the introduction of STEM Education in the Philippine basic science education.

The Philippine Basic Science Education and the K to 12 Curriculum

The Philippine basic science education was initially faced with different problems and issues like “shortage of qualified science teachers, lack of quality textbooks, the discipline-based curriculum for basic education, and predominance of teacher-centered classrooms” (SEI-DOST & UP NISMED, 2011). The country’s ranking in the Trends in International Mathematics and Science Study (TIMSS) in 1996, 1999, 2003, and 2008 showed discouraging results, the worst was in 2003 when the country ranked 39 out of 41 participating countries (Cordova & Tan, 2018; Imam, 2016; Imam, Abas-Mastura, & Jamil, 2013; Ogena, Lana, & Sasota, 2010). These dismal results are validated by the unpromising performance of the students in National Achievement Test (NAT) in science and mathematics for the year range 2003-2009, where about one million fourth year



Philippine Normal University National Center for Teacher Education

students and more showed only 10% mastery in science and mathematics (Bernardo, Limjap, Prudente, & Roleda, 2008; Lumaque, Sarraga, & Jumawan, 2005; Rimando, 2006). These challenges necessitate an educational reform that will address the needs of students and society in science and technology in general to improve national and international standards and metrics.

In 2011, an educational reform was proposed with the following objectives: (1) the curriculum on that time be decongested; (2) the students be more prepared in higher education; (3) the students be empowered and equipped for the labor market; and (4) the country's education be compliant with the global standards (Magno, 2011; Yap, 2011). It was approved in 2013 and is now known as the K to 12 Enhanced Basic Education Curriculum. Starting that year, the basic education curriculum of the Philippines changed from 10 years to 12 years of formal schooling. Backed up by RA 10533 also known as "Enhanced Basic Education Act of 2013", the new curriculum created another level of basic education known as senior high school (SHS) program, expanding the length of the schooling for at least a year in kindergarten level, six years in the elementary level, four years of junior high school, and the additional two years in the senior high school (Estonanto, 2017; Montebon, 2014). The salient features of this curriculum include "strengthening early childhood education (universal kindergarten); making the curriculum relevant to the learners (contextualization and enhancement); ensuring integrated and seamless learning also known as spiral progression; building proficiency through language (Mother tongue-based multilingual education); gearing up for the future (senior high school); and nurturing the holistically developed Filipino (College and



Philippine Normal University National Center for Teacher Education

Livelihood Readiness)” (Official Gazette, 2013). In addition, one of the notable features of the curriculum is that it is mandated to use pedagogical methods that are reflective, constructivist, collaborative, integrative, and inquiry-based that promotes active learning. This educational shift aims to meet global education standards so that our graduates will be equipped for globalization (Acosta & Acosta, 2017). Furthermore, the K to 12 program focuses on enhancing the curriculum and producing holistically developed individuals fortified with 21st Century skills essential for life-long learning and job opportunities for globalization (Official Gazette, 2013).

To achieve quality science education, the K to 12 science curriculum is suitably drafted to provide the learners with a list of competencies needed for globalization. The science curriculum is designed around the three areas of learning: “1) understanding and applying scientific knowledge in a local setting as well as global context whenever possible; 2) performing scientific processes and skills; and 3) developing and demonstrating scientific attitudes and values,” facilitated by active learning pedagogy approaches (Figure 5). From this perspective, K to 12 science curriculum envisions

“... the development of scientifically, technologically, and environmentally literate and productive members of society who are critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision makers, and effective communicators”
(K to 12 Science Curriculum Guide, 2016, p. 2).

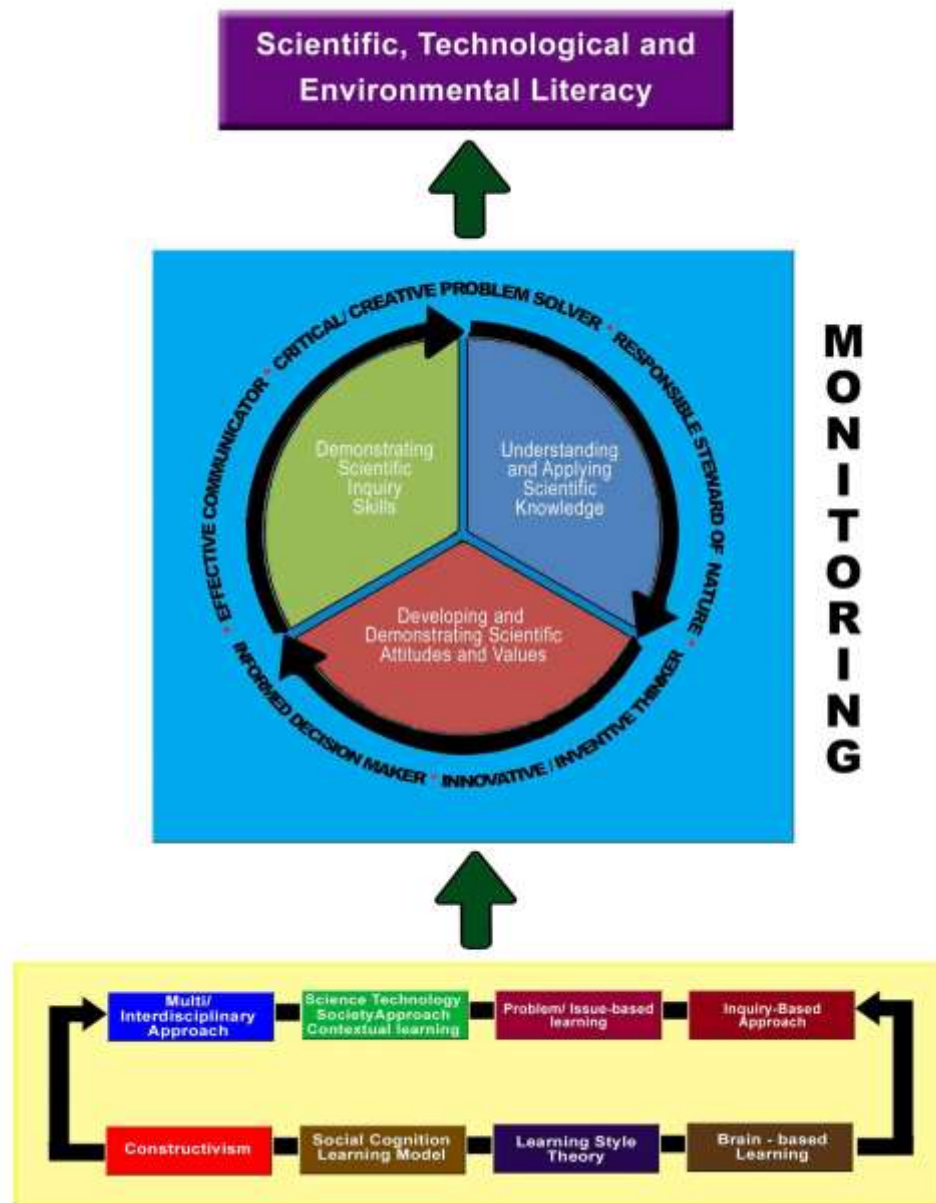


Figure 5. *K to 12 Framework of Science Education (Figure from K to 12 Science Curriculum Guide, 2016)*

However, the Philippine basic education system was put in the spotlight when the 2018 Organization for Economic Cooperation Programme for International Student



Philippine Normal University National Center for Teacher Education

Assessment (PISA) score for the Philippines gave a dismal result. PISA is an international assessment conducted every three years aiming to assess the “15-year-olds’ ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges” (Schleicher, 2019, p.4). As Sjøberg (2019) pointed out, “PISA result has become the global gold standard for educational quality; and in many countries, educational reforms are launched as a direct response to it” (pp. 12-13). Our performance in reading (score of 340) is way too low from the average score of 487 that put the Philippines lowest among the 79 participating countries, and given a low Level 1a (from 334.75 to less than 480.18 score points). Worst is in mathematics when the Philippines only got a score of 353 compared to the average score of 489, which positioned the country second to the last, beating only the Dominican Republic. This score rated the Philippines based on the PISA scale as “Below Level 1” proficiency in mathematics. In terms of science, the Philippines having a score of 357 (PISA Average = 489) got Level 1a science proficiency in the PISA Scale (OECD, 2019; Punongbayan, 2019; Schleicher, 2019).

From this result, Filipino students are described as low performers or low achievers. OECD (2016) defines low performers or low achievers as “those students who score below Level 2 on the PISA mathematics, reading and/or science scales” (p. 37). Additionally, “Level 2 is considered the baseline level of proficiency that is required to participate fully in society. Students who score at Level 1 can answer questions involving clear directions and requiring a single source of information or simple connections, but



Philippine Normal University National Center for Teacher Education

these students cannot engage in more complex reasoning to solve the kinds of problems that today's adults in modern societies routinely face" (OECD, 2016, p. 37).

This dilemma may suggest that a need to replace the traditional methods of an educational approach that focus only on 3R's (reading, writing, and arithmetic) is wanting. Innovative science teaching approaches like STEM and STEAM Education may work miracles. At the Philippine basic education level, STEM Education is being implemented in the STEM Strand of senior high school.

Senior High School (SHS) STEM Strand

When the K to 12 Curriculum was enacted, the Senior High School (SHS) found its niche in the Philippine basic education curriculum. The senior high school allows the students to focus more on the mastery of learning as preparation for their intended courses in college. The core disciplines such as Science, Mathematics, and Language were enhanced and fortified to realise this.

The additional two years for SHS is expected to prepare and train the learners with craft and skills that will equip them for entrepreneurship, employment, higher education, or skills development (Garcia et al., 2017; Dumapias & Tabuzo, 2018). Aligned with this, the SHS offers four tracks namely sports, arts and design, technical-vocational-livelihood (TVL), and academic track. Junior High School completers may choose among these tracks that will suit them based on the college course that they want to enroll in after senior high school graduation. Common among these four tracks are the eight learning areas in the core curriculum such as social science, physical education and



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health, language, science, philosophy, humanities, communication, and mathematics (Figure 6).

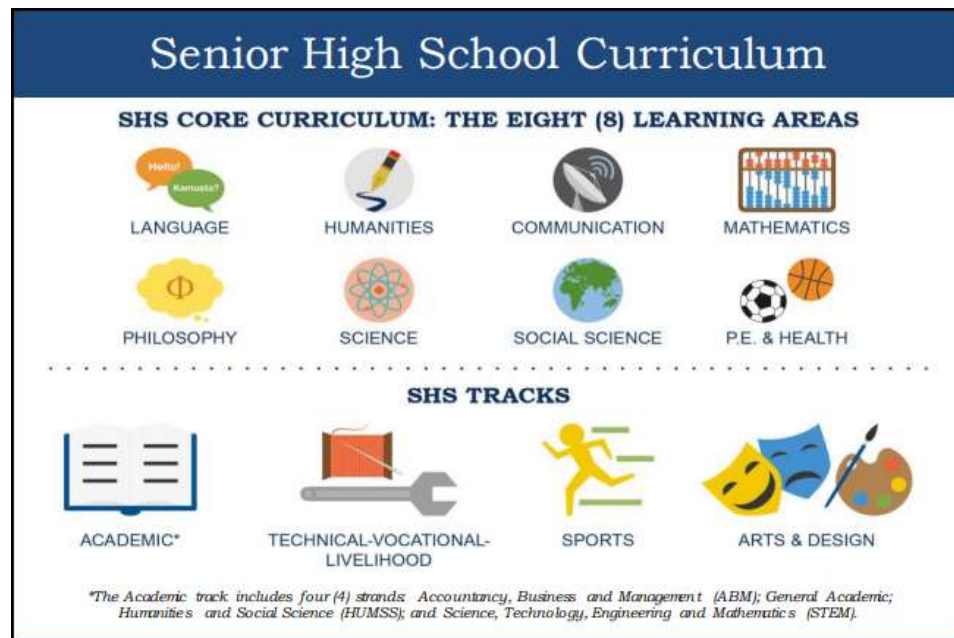


Figure 6. The tracks and eight core learning areas of the Senior High School Curriculum (Figure from <http://industry.gov.ph/wp-content/uploads/2015/05/6th-TID-Usec.-Ocampos-Presentation-on-K-to-12.pdf>)

Additional subjects will be based on the students' chosen strand. There are four learning strands for the academic track to wit: Accountancy, Business, and Management (ABM), General Academic Strand (GAS), Humanities and Social Sciences (HUMMS) and Science, Technology, Engineering, and Mathematics (STEM) Strand (Arnilla, 2018). The GAS strand is the best option for students who have not yet decided on their chosen careers, unlike the other strands that are tailored specifically for students who already have courses on their minds. Education courses such as Bachelor of Secondary Education



Philippine Normal University National Center for Teacher Education

(BSEd) and Bachelor of Elementary Education (BEEd) are some of the courses for this track. Meanwhile, HUMMS are for students who want to pursue careers in the field of social sciences and humanities such as psychology, philosophy, English, literature, among many others.

Further, ABM Strand offers subjects for students interested in the field of accountancy and business leading to the courses such as BS Accounting Technology, BS Hotel and Restaurant Management, and BS Business Administration, among others. Furthermore, graduates of STEM Strand are expected to take courses in the STEM field such as BS Chemistry, BSBiology, BSCivil engineering, etc. The STEM Strand contains highly specialized subjects in relation to the STEM fields (Table 1).

Table 1. The schedule of specialization subjects for students who are in STEM Strand
(Taken from <https://www.deped.gov.ph/wp-content/uploads/2019/01/Science-Technology-Engineering-and-Mathematics-STEM-Strand.pdf>)

Specialization Subjects			
Grade 11		Grade 12	
1 st Sem	2 nd Sem	1 st Sem	2 nd Sem
Pre Calculus	Basic Calculus General Chemistry 1	General Physics 1 General Biology 1	General Physics 2 General Biology 2 General Chemistry 2 Research/Capstone Project

The STEM Strand is envisioned to answer the country's perennial problem of the lack of science and mathematics practitioners. By this strand, an increase in the STEM professionals in the Philippines is expected (Estonanto, 2017). The SHS STEM Strand is



Philippine Normal University National Center for Teacher Education

believed to be anchored on the former Engineering and Science Education Program (ESEP) of the Department of Science and Technology in 1994 (Estonanto, 2017). The initial assessment for the STEM Strand is exceptional since Orale and Sarmiento (2016) found that this strand is much organized than that of the US and Japan. In this high hope, authorities believe STEM Strand will lead Filipino learners to better work abroad (Cabansag, 2014). STEM Strand is designed to prepare and encourage senior high school students to take science-related courses at their tertiary level. The skills they will gain during their stay in the STEM strand will help them prepare as future STEM workforce of the country. As Tupas and Matsuura (2018) pointed out,

“SHS STEM Strand is hope to develop learners’ skills from simple to complex problems in the country and the world as well in terms of science, technology, engineering, and mathematical concepts”(p. 408).

As of 2019, the average teacher-student ratio in STEM Strand is 1:29. Notable challenges and issues of STEM Strand recorded by DepEd include insufficient mathematics and science equipment and learning resources, negative perception of STEM teachers on the delivery of lessons, limited training programs for STEM teachers, lack of qualified STEM teachers, and the seeming disjoint between the junior high school science and mathematics with that of SHS (Victorino, 2019).

In sum, the primary goal of quality science education is to provide the students with the necessary knowledge and skills to prepare the students as the country's future workforce. The need for 21st Century skills and Future skills is so important today to cope with this era of Industry 4.0. This life, learning, and literacy skills have been so essential



Philippine Normal University National Center for Teacher Education

that quality science teaching has gained much attention from the government for the learners to imbibe the 21st Century skills and Future skills thoroughly. Quality science teaching involves the instructional practices, teacher's methods and theories in teaching science. Many first-world countries like the United States and Canada believe that quality science education can be achieved through STEM Education. STEM Education is an approach consisting of four areas or disciplines: Science, Technology, Engineering, and Mathematics. As a technology-based approach, the literature points out the benefits of using this approach in the learners' competency, especially in honing their 21st Century and Future skills. Other educators, however, contend that concentrating on the highly technical subjects of STEM is not enough. They believe that the learners must be holistically developed and must reach their full potential. From the studies, analytical subjects such as STEM consider only the left brain of the learners while the right brain is left behind. From this context, STEAM education where Arts is integrated into the STEM fields, was born. The integration hopes the Arts field will bring to the fore the creativity among students. Thus, STEAM stands for Science, Technology, Engineering, Arts, and Mathematics. In the case of the Philippines, contextualization made STEAM education integrate Agri-fishery and the Arts field in STEM. Thus, in Philippine Higher Education, STEAM Education has found its niche.

The data show that the Philippine STEM Workforce in the industry is still wanting. The available literature suggests the lack or a limited research on STEAM Education in senior high schools in the Philippines. Evidently, STEAM Education has not yet gained much patronage and prestige in the Philippines, thus, the limited research on



Philippine Normal University National Center for Teacher Education

the trends and issues which are imperative for it to prosper. Even though STEAM Education is somewhat pronounced at the tertiary level, it hopes to benefit more from the quality of science education by embedding and implementing it in the foundational learning of the students. Hence, senior high school must be at the forefront of consideration. It is crucial since many researchers consider secondary level as the most problematic years in teaching science primarily because the students see science as an abstract subject and do not appreciate its application.

However, the absence of a concrete framework for implementation may only hamper this endeavor. The lack of framework may only result in unorganized implementation. The perceived barriers and challenges by the teachers as well as by the administrators could aggravate this problem. Through the Department of Education (DepEd), the Philippine government implemented the K to 12 Curriculum in 2013 to ensure quality science education in the country. As an innovation to this curriculum, the STEM Strand under SHS academic track was offered at the forefront of STEM Education. Researches revealed that the current STEM Education of the country might inform the framework for STEAM education.

Thus, to fully grasp STEAM Education in the Philippine context, a framework contextualized on the STEM Education of the country is needed. The developed STEAM Education framework and the training design and the indicators and standards generated from the framework may benefit many as these outputs are vital to the development of the stakeholders such as teachers, administrators, and learners.



Conceptual Framework of the Study

Adoption of a new approach or curriculum is found to be complicated. Policy makers are faced with the challenges and barriers that affect the implementation. There are many reports that some educational approaches or curriculum are planned well in the beginning stage, but not all that was planned was implemented as intended afterwards (Karakus, 2021; Nevenglosky, Cale, & Aguilar, 2019). This is expected as implementation requires concerted efforts and broad participation from stakeholders such as teachers, administrators, and students. Boon (2018) detailed in his study how complex the implementation is as “it often requires restructuring habits, reforming thoughts, and deeper conceptual understanding of instructional methodology among the implementers” (p. 24). It cannot be argued that the modality and means of implementation are crucial for the success of any innovation. As Asebiomo (2009) stated, “no matter how well formulated a curriculum or educational approach may be, its effective implementation is a *sine qua non* toward achieving the desired goals of education” (p. 125). Therefore, the effectiveness of an educational approach greatly relies on the effectiveness of implementation.

STE[Arts]M Education as an approach is also beset with these problems. The perceived challenges and barriers by teachers and administrators inherent in this new method are surprising. The paradigm shift from STEM Education to STE[Arts]M Education constitutes many changes and not so easy acceptance from the stakeholders (Belbase, 2019). Teachers are the most affected. Adopting STE[Arts]M Education into



Philippine Normal University National Center for Teacher Education

teachers' pedagogical practices appears to be challenging since teachers consider such a new mindset, thus affecting their self-efficacy in this approach (Kim & Bolger, 2017; Mejia, 2011; Polgampala, Shen, & Huang, 2017). Also, teachers must learn new skills in teaching this approach for them to be able to become effective. Teachers must be immersed and actively involved in STE[Arts]M Education for them to learn, be updated, and be upgraded. Zimmerman (2016) perceived STEAM education as an ambitious approach. The arts integration coupled with the authentic assessment and contextualization in the real-world situation makes it hard for teachers to adapt to this new method. Studies revealed that novice teachers in STE[Arts]M education teach it superficially in the early years of teaching. For years, the implementation of STE[Arts]M Education has been a challenging process for many educators, even abroad.

Thus, a framework needs to be established to overcome these problems in implementation. Edelmann (2006) recommends that a framework has to be designed in such a way that “it will help to identify and reveal relationships among complex, related, interacting phenomena; in effect to reveal the whole where wholeness might not be thought to exist. Such a framework consists of categories abstracted from the existential phenomena” (p. 12). The framework can be used to ensure relevant, consistent, and up-to-date governance of STE[Arts]M education. Some frameworks have been developed to implement STE[Arts]M education in other countries successfully, but this cannot be used per se because of the cultural and contextual differences between schools and different countries. This is in consonance with the situated learning theory, which posits that an individual's learning is situated within context, authentic activity, and culture (Korthagen,



Philippine Normal University National Center for Teacher Education

2010). Due to such, uniqueness among learners and educational institutions in different countries is evident. Thus, no STE[Arts]M Education framework can have the same features. It is therefore vital that the Philippines formulate and design its own framework for efficient and effective outcomes. Research indicates that this framework may be informed by the existing STEM curricula in the country (Kang, 2019; Moon, 2020). Information and knowledge about STEM instruction and STEM school implementation provide possible indicators about STE[Arts]M Education (Kang, 2019; Moon, 2020). In the Philippines, the senior high school STEM Strand has been enacted for four years now. It started when the K to 12 Curriculum was implemented in 2013. A significant feature of the Philippine K to 12 Curriculum is the offering of choices for the students in establishing or determining their respective career paths. There are four choices termed as tracks namely technical-vocational-livelihood (TVL), sports, arts and design, and academic which aim to guide and enhance the student's ability in his chosen career path. STEM Strand is one of the four strands in the Academic Track (Rabacal & Alegato, 2017). In the Philippine higher learning, STEAM is contextualized to the needs of the country by integrating Agriculture and Fisheries in the STEM Education; thus, STEAM initially stands for Science, Technology, Engineering, Agriculture-Fisheries, and Mathematics (CHED, 2015). In this regard, the term, STE[Arts]M, was conceptualized to differentiate STEAM Education where A is agriculture or agri-fisheries. Thus, in the context of the study, all STEAM Education mentioned in the study refers to STE[Arts]M which is the blending of Arts with the STEM Field.



Philippine Normal University National Center for Teacher Education

The prime goal of this study is to develop a STEAM Education Framework for Senior High School (SHS) STEM Strand. One of the intentions of this framework is to serve as a blueprint for the Department of Education (DepEd) in the implementation of STEAM education at the senior high school level which eventually could familiarize SHS science teachers on STEAM instructional models that could shape their school and classroom practices. Figure 7 shows the *a priori* conceptual framework of the study. Maeda (2013) stated that teachers' and administrators' perceptions are vital in implementing STEAM Education. Hence, to provide information for the possible implementation of STEAM Education in the SHS, the needs and constructs of SHS STEM Academic track in terms of the pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, and other qualitative parameters were conducted in the lens of the teachers and administrators. Using the Strauss and Corbin (1990) evolved grounded theory approach as a qualitative means of interpreting participants' perspectives and providing meaning, a STEAM Education framework was developed.

As part of the validation process of the STEAM Education framework, a training design for the teachers and indicators and standards on STEAM Education in SHS were developed. The training design for teachers involves designing or developing a training program for effective and efficient acquisition and application of knowledge. This training program was anchored on the developed STEAM Education Framework and was intended to serve as a blueprint for future training on STEAM Education for SHS STEM Strand science teachers. Meanwhile, indicators and standards aim to provide an objective



way of measuring and demonstrating the success of the implementation of STEAM Education. The indicators and standards were the qualitative or quantitative markers or pointers derived from the developed STEAM Education Framework to assess the outcomes, outputs, and impact of STEAM Education in SHS.

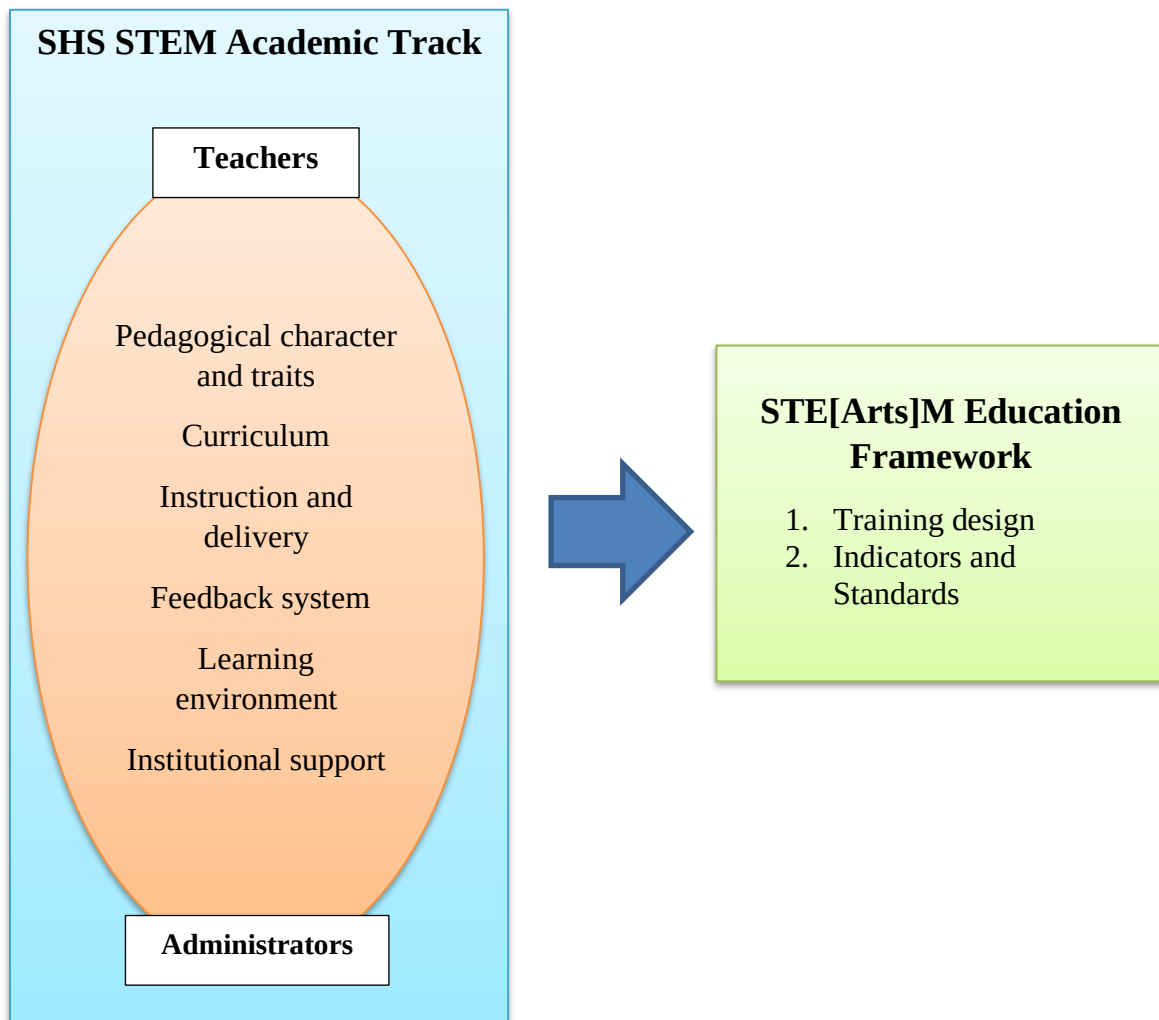


Figure 7. *Conceptual Framework of the Study*



Philippine Normal University National Center for Teacher Education

The quality standards for implementation, the teachers' and administrators' perceived challenges and barriers in the current curriculum, and the information extracted on the needs and constructs of SHS STEM Academic track in terms of different qualitative factors were considered in developing the STEAM Education Framework for Senior High School (SHS) STEM Strand. Through these parameters, a framework along with training design and indicators and standards were the outputs.

Research Questions

This study aimed to develop a STEAM Education Framework for Senior High School (SHS) Science, Technology, Engineering and Mathematics (STEM) Strand. Specifically, it sought to answer the following questions

1. What are the needs and constructs of SHS STEM Strand from different types of high school in Nueva Ecija on the perspective of teachers and administrators in pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, among others for the implementation of STEAM Education?
2. How can these needs and constructs inform the design of a STEAM Education Framework for SHS STEM Strand?
3. What modifications are needed to improve the developed framework based on validation processes:
 - a. What inputs may be derived from experts?



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- b. What are the elements and processes of a training design that can be derived from the developed framework?
- c. What are the indicators and standards for STEAM Education in SHS that can be derived from the framework?

Significance of the Study

Generally, this study aimed to develop a STEAM Education Framework for Senior High School (SHS) Science, Technology, Engineering and Mathematics (STEM) Strand. The study targets to lay a foundation and promote STEAM Education/Approach as an integral educational approach relevant to the Philippine Basic Science Education which will contribute to the continuous improvement of science and engineering education at the tertiary level. The realization of this goal will ensure the production of competent scientists and professionals in the STEM field. Various entities are expected to benefit from this study. Specifically, the following will be benefited from the study.

Community. Society will be exposed to STEAM Education as an approach in classroom learning which has not yet passed its infancy stage in the Philippines. Also, the expected outputs of the study are contributions to the community for a better STEAM and STEM literacy that is important for future technological advances that will drive the economic market and scientific innovations forward.

Academe. The study will indirectly contribute to the production of competent scientists and professionals in the STEM field.



Philippine Normal University National Center for Teacher Education

Department of Education. The study could serve as a blueprint for the Department of Education (DepEd) on implementing STEAM Education in SHS. The developed training design could be used as a guide for future training, conferences, and workshops for science teachers. The findings from the study could be the baseline for policy making and in providing pedagogical know-how to teachers. The study is expected to enhance educational policies and serve as a basis for STEAM instruction. The indicators and standards derived from the developed framework will also help DepEd plan, monitor, manage, and assess implemented STEAM Education at the SHS level.

Senior High School Teachers. The developed framework aims to help senior high school science teachers learn a new approach to promote quality science education. Through the STEAM Education approach, teachers' instructional practices could be enhanced and their teaching could be more engaging, thereby achieving quality science teaching. Also, through this framework, the science teachers may be equipped to prepare the students as the country's future workforce. Moreover, the developed training program from the training design can contribute to the professional growth of the teachers.

Students. The STEAM approach used in the study may promote more active learning for the students and enhance their capabilities, especially the necessary skills needed in this era of the 4th Industrial Revolution known as 21st Century Skills and Future Skills.

Future Researchers. The study can serve as a reference for future studies related to STEAM Education.



Philippine Normal University National Center for Teacher Education

Scope and Limitations of the Study

The study mainly focused on designing and developing a STEAM Education Framework for senior high school (SHS) STEM Strand. The research determined the needs and constructs of the SHS STEM Strand in terms of the pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, and institutional support interview, and other qualitative means from the lens of the teachers and administrators. The STEAM Education Framework along with the developed training design and indicators and standards were the outputs. The participants of the study were SHS teachers and administrators from STEM Strand who were from different types of high school namely private schools with SHS, public schools with integrated JHS and SHS, public schools with stand-alone SHS, public Higher Education Institution (HEI) with SHS, and private HEI with SHS in Nueva Ecija. The interview was conducted through online platforms such as Zoom, Google Meet, Cisco WebEx and Microsoft Teams (MS Teams). Confidentiality of the statements of the teachers and administrators were assured. Instruments such as interview guides and validation questionnaires were validated. The framework, training design, and sets of indicators and standards developed were not tested and validated through implementation to the schools. The data and results were limited to the interviewed teachers and administrators, the experts, and those who shared similar experiences and characteristics. The timeframe of the study was sixteen months, from August 2020 to December 2021.



Philippine Normal University National Center for Teacher Education

Definition of Terms

The following are defined conceptually or operationally for a clearer understanding of the study.

STEM Education/Approach. This refers to the integration of four subjects/disciplines, namely mathematics, science, engineering, and technology, which could develop 21st Century Learning Skills and future skills.

STEAM Education/Approach. This refers to the integration of Arts in STEM discipline to nurture creativity among the students.

Senior High School. This is the additional two years after junior high school. It was created when K to 12 curriculum was implemented in the Philippines.

STEM Strand. This is one of the strands under the Academic Track of the senior high school program in the Philippines. The expertise is in the field of science, technology, engineering and mathematics (STEM) and graduates of this strand are expected to take courses in the STEM field.

STEAM Education Framework. This refers to an essential system or structure that can be used as a foundation for implementing STEAM Education in senior high school. This is tailor-made and custom-designed for the SHS STEM Strand.



Philippine Normal University National Center for Teacher Education

Training Design. This refers to the design or developed training program in a stylish way for effective and efficient acquisition and application of knowledge. This is anchored to the developed STEAM Education Framework and intends to serve as a blueprint for future STEAM Education training for SHS STEM Strand science teachers.

Indicators and Standards. These are qualitative or quantitative markers or pointers sourced from the developed STEAM Education Framework that assess the outcomes, outputs, and impact of STEAM Education in SHS. These provide an objective way of measuring and demonstrating the success of the implementation of STEAM Education.

Grounded Theory. This is a qualitative approach that is used in the study as the methodological framework.

Administrators. They are the immediate supervisors of STEM teachers and the direct overseer of the STEM Strand in the school.

STEM Teachers. They are teachers in the SHS STEM Strand – Academic Track who handle science and mathematics subjects such as Calculus, Physics, Biology, Chemistry, Research/Capstone projects and other specialized subjects offered in the school.



CHAPTER 2

METHODS

This chapter situates the study within research methods and design, provides a justification for the method, describes the sample and research setting, and explains data collection and analyses, such as sampling, coding, and constant comparison method.

This section offers an extensive description of all aspects of the procedure and design of the study. The use of field notes, case summary through a contact summary sheet, and memoing were appreciated to facilitate in-depth qualitative analysis. A detailed explanation was presented to deliver data validity, reliability, and determine the researcher's bias.

This chapter also presents the process of how the framework was generated and validated. The development and validation of training design and a set of indicators and standards in accordance with the developed framework were extensively discussed in this part. Lastly, the ethical considerations like approval of the concerned schools and handling of the data collected were described.

Research Design

The study employed a grounded theory approach. Foley and Timonen (2015) described grounded theory (GT) as “a systematic set of techniques and procedures that enable researchers to identify concepts and build theory from qualitative data” (p. 1197). GT as a qualitative strategy is usually related to theory building, modelling, and



Philippine Normal University National Center for Teacher Education

generating framework. Also, Creswell (2007, p. 63) defined GT as “a strategy of inquiry where the researcher derives a general, abstract theory of a process, action of interaction grounded in the views of the participants.” The fundamental idea of this technique that differs from other qualitative approaches (narrative, ethnography, case study, and phenomenology) is that the theory is “grounded” on the participants’ meaningful and rich experiences on the topic or subject.

GT is based on symbolic interactionism. According to Pitney and Ehlers (2004, p. 345), “symbolic interactionism infers that an individual's behavior is formed by social interactions; individuals are active in this process, and they make conscious decisions about how they will act in a given situation.” Thus, this social interaction contributed to individuals’ experiences and perceptions toward the subject of study. In GT, the data analysis is more inductive; the explanation of phenomenon through qualitative data is from specific to general. The data can be collected through observation, interviews, documents, or audiovisual materials (Tie, Birks, & Francis, 2019). The idea is to saturate the information through these methods. Creswell (2007) suggested that to saturate the model fully, it may involve 20 to 30 or 50 to 60 interviews.

Generally, there are three types of GT in use today, namely: the constructivist grounded theory of Charmaz (2006), the evolved grounded theory of Strauss and Corbin (1990), and the traditional grounded theory of Glaser and Strauss (1967) (Mills, Bonner, & Francis, 2006). In the evolved GT, the study systematically develops a theory through methodological data analysis (code, category, and themes). The theory developed through this type of GT is a visual picture, a narrative statement, or either a hypothesis or



Philippine Normal University National Center for Teacher Education

proposition. Meanwhile, the constructivist GT believes in the flexibility rules of GT such that it should not be a single process and must be interpretative in nature. In this type of GT, participants construct meaning and the conclusions generated from the study are described as incomplete, inconclusive, and suggestive. On the other hand, Glaser (1978) GT claims that the researcher should have no prior knowledge or predetermined thoughts to avoid the researcher's bias as possible. In this GT, objectivity is maintained throughout the study.

From this perspective, the researcher believes that GT is the best method suitable in this study to develop a STEAM Education Framework for Senior High School STEM Strand. With regard to the type of GT, the evolved grounded theory of Strauss and Corbin (1990) was used. In the study, the researcher used predetermined questions as a guide, opposite the Glaser (1978) GT, which proposed that the researcher view the topic without preconceived ideas. Further, Charmaz (2006) and Strauss and Corbin (1990) GTs are proven to be more user-friendly for novice researchers than Glaser (1978) GT in terms of data analysis (Cooney, 2010; Rieger, 2018). Furthermore, Strauss and Corbin (1990) GT is more appropriate in the study as it develops theory and framework. This is in contrast with Charmaz (2006) GT as it claims that the generated theories will be incomplete, inconclusive, and suggestive (Creswell, 2007) which does not adhere to the goals of the study.



Research Setting

For convenience, the study was conducted in Nueva Ecija, the home province of the researcher. The province of Nueva Ecija is situated in Region 3 or Central Luzon which is also the largest province in the region with a land area of 5,751.33 square kilometers. It is adjacent to the provinces of Bulacan (south), Pampanga (southwest), Tarlac (west), Pangasinan (northwest), Nueva Vizcaya (north and northeast), and Aurora (east and southeast) and is composed of four congressional districts (Figure 8). Furthermore, Nueva Ecija is considered as the ‘Rice Granary of the Philippines’ since it is the top producer of rice in the country, but the province also produces other agricultural products such as corn, onion, banana, mango, calamansi, garlic, and other vegetables.



Figure 8. Map of Nueva Ecija showing (a) its neighboring provinces and (b) congressional districts



Philippine Normal University National Center for Teacher Education

The province of Nueva Ecija is composed of 27 municipalities and five cities, the most significant number of cities in a province in Central Luzon. Its capital is the Palayan City and has the only science city in the Philippines, and second in the world after Japan, the Science City of Muñoz. Patterned from these cities, the Department of Education has five divisions in Nueva Ecija as shown in Figure 9 with color coding to wit: Division of Science City of Muñoz (blue), Division of San Jose City (orange), Division of Cabanatuan City (red), Division of Gapan City (light blue), and Division of Nueva Ecija (consisting of Palayan City and 27 municipalities colored in lavender in Figure 9).

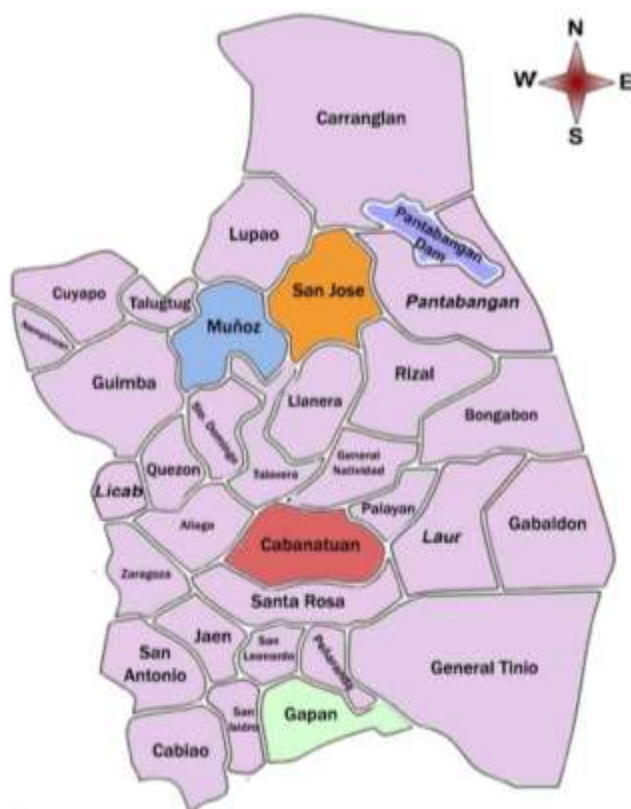


Figure 9. *The five DepEd Schools Division in Nueva Ecija [Division of Science City of Muñoz (blue), Division of Cabanatuan City (red), Division of Gapan City (light blue), Division of San Jose City (orange), and Division of Nueva Ecija (composing of Palayan City and 27 municipalities colored in lavender)]*



Philippine Normal University National Center for Teacher Education

As Nueva Ecija is an agricultural province, a curriculum that focuses on agriculture was already offered for secondary schools. One of the schools which offers this curriculum is the Agricultural Science and Technology School (ASTS) located at Science City of Munoz, Nueva Ecija with the main objective of “to train future farmers the modern ways of farming applying new technological innovations to upgrade agricultural produce” (Gaboy et al., 2019). With this information, STEAM education in this study focused on A as Arts rather than Agriculture since the agriculture curriculum is already implemented in some schools. Moreover, agriculture is also considered science which may deviate from the goal of the study in which to introduce a novel approach in education that involves design and creativity in the STEM approach. Furthermore, the Arts for these agricultural schools may help packaging their products for their income-generating projects (IGPs).

Sampling and Participants

In this study, the participants were senior high school (SHS) science and mathematics teachers and administrators in STEM Strand. It was noted that there were different types or classifications of senior high schools that offer Academic - STEM Strand based on the supervising institutions which may affect the result if not considered. The onset of the K to 12 program provided an avenue for the Commission on Higher Education to offer the senior high school in private and public higher education institutions (HEIs) to mitigate the displacement of college teachers due to the two-year



Philippine Normal University National Center for Teacher Education

gap when the senior high school was created. Also, private secondary schools were allowed to offer senior high school after satisfying the requirements set by the Department of Education (DepEd).

Furthermore, DepEd institutionalized public senior high school classification as stand-alone or integrated through DepEd Order No. 19 s. 2016 titled “*Guidelines on the Organizational Structures and Staffing Patterns of Stand-alone and Integrated Public Senior High Schools (SHS)*.” This document defines stand-alone SHS as a school detached from a junior high school (JHS) or integrated school (IS) and has its own school principal or head. Meanwhile, integrated SHS was defined as a senior high school placed with a JHS or IS and shares a school head with JHS or IS. Moreover, stand-alone SHS and integrated SHS were further classified based on the enrolment to wit: small (less than 440 enrollees), medium (441 – 840 enrollees), large (841 – 1240 enrollees), and very large (1241 and above enrollees). However, these sub-classifications were not considered and DepEd SHS Schools were only classified as stand-alone and integrated SHS in the study. Thus, different SHS offering STEM-academic strand in Nueva Ecija in this study were categorized into five to wit: (a) Public Higher Education Institutions (HEIs) with SHS, (b) Private HEIs with SHS, (c) DepEd stand-alone SHS, (d) DepEd integrated SHS, and (e) Private SHS. All types of senior high school were included so that variations due to the type were eliminated.



Philippine Normal University National Center for Teacher Education

Table 2. The number of SHS offering STEM Strand per classification and per division in the province of Nueva Ecija.

Division	Public HEIs with SHS STEM Strand	Private HEIs with SHS STEM Strand	Private schools with SHS STEM Strand	DepEd stand- alone SHS with STEM Strand	DepEd integrated SHS with STEM Strand	Total
Cabanatuan City	1	10	0	1	5	17
Gapan City	0	2	1	0	3	6
Nueva Ecija	0	6	16	3	20	45
San Jose City	0	0	1	1	0	2
Science City of Muñoz	1	0	1	1	0	3
Total	2	18	19	6	28	73

From the list provided by the DepEd Region III office (Appendix A), 73 senior high schools that offer STEM Strand in Nueva Ecija were noted. From the list, 17 are in Division of Cabanatuan City, six (6) are in Division of Gapan City, 45 are in the Division of Nueva Ecija, two (2) are in the Division of San Jose City, and three (3) are in Division of Science City of Muñoz. Based on the SHS classification, there are two (2) Public HEIs with SHS, 18 Private HEIs with SHS, 19 Private SHS that offer STEM Strand, six (6) DepEd stand-alone SHS, and 28 DepEd integrated SHS in the province of Nueva Ecija (Table 2). Figure 10 shows the geographical distribution of SHS offering STEM Strand in the province (please see Appendix B for a larger figure).

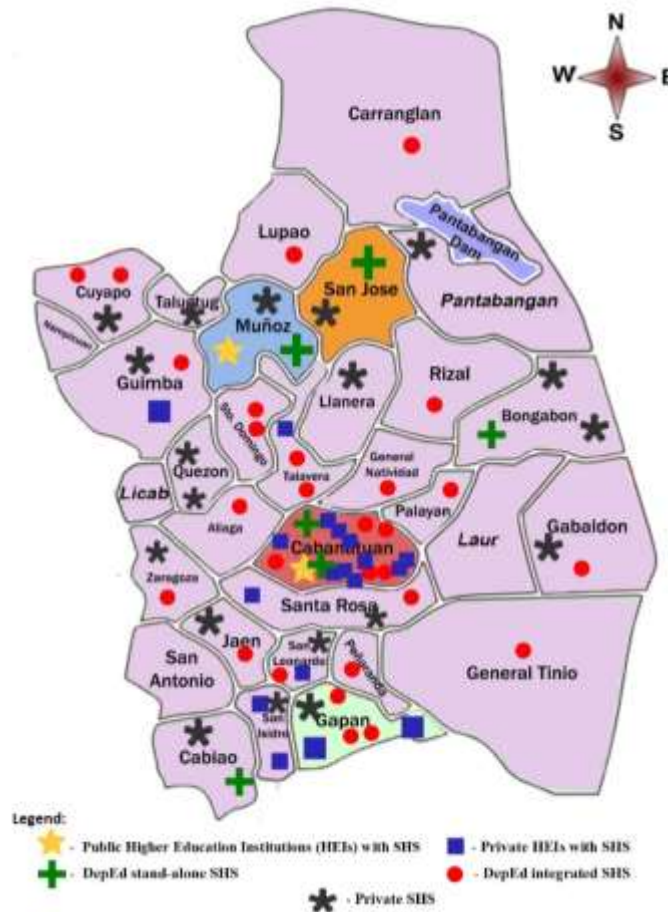


Figure 10. A map of Nueva Ecija showing the geographical distribution of senior high schools offering STEM strand in the province as of SY 2020-2021.

To have representative teacher-participant and administrators for each type of senior high school offering STEM strand in Nueva Ecija, stratified purposive sampling was used initially. As Patton (2002) explains, “the purpose of a stratified purposive sampling is to capture major variations rather than to identify a common core, although the latter may also emerge in the analysis. Each of the strata would constitute a fairly homogeneous sample” (p. 240). Two schools for each type were chosen using stratified



Philippine Normal University National Center for Teacher Education

purposive sampling through the Fishbowl technique or lottery random sampling. However, only SHS with STEM Strand that existed for three years or more were included in the list used in the sampling. At present, SHS has existed for four years now since the K to 12 was enacted. A lottery was no longer used for the public HEIs with SHS STEM Strand since there are only two HEIs in Nueva Ecija offering the STEM Strand. Fortunately, these HEI SHS offering STEM strands have been existing for four years to date so the qualification set for the SHS to be included in the study was met.

Table 3 shows the distribution of SHS offering STEM Strand per division in Nueva Ecija that were selected randomly using the Fishbowl technique. Initially, there were ten participating schools in the study. However, an additional school (DepEd integrated SHS) in the Division of Cabanatuan City selected through the Fishbowl technique was included to confirm data saturation.

From the chosen schools, senior high school (SHS) science and mathematics teachers in STEM Strand and their immediate supervisors were selected as participants. Science and mathematics teachers were only considered since core subjects were common to all strands in academic track [Humanities and Social Sciences (HUMMS), General Academic Strand (GAS), Accountancy, Business, and Management (ABM), and Science, Technology, Engineering, and Mathematics (STEM) Strand] and the differences lie on each strands' specialized subjects. The STEM Strand has specialized subjects such as Calculus, Physics, Biology, Chemistry and Research/Capstone Project.



Philippine Normal University National Center for Teacher Education

Table 3. The number of SHS offering STEM Strand that was randomly selected per division in the study.

Division	Number of SHS participated in the study
Cabanatuan City	1
Gapan City	1
Nueva Ecija	5
San Jose City	1
Science City of Muñoz	2
Total	10

The construct of the STEM Strand could be fully understood and explained by those who taught these subjects. Also, only science and mathematics teachers with teaching experience in the STEM strand of three years or more were selected. This is to ensure that the construct generated from the participants was based on their long experience in the school. Professional rank was not set as a qualification for the study since a novice teacher may get the rank of master teacher for SHS even though they are newly hired as long as they met the hiring requirement for that rank in accordance with DepEd Order No. 3 s. 2016 [*“Hiring Guidelines for Senior High School (SHS) Teaching Positions effective School Year (SY) 2016 – 2017”*].



Philippine Normal University National Center for Teacher Education

For the administrators, a qualification was set in the study that they should be in the position for at least three years. In this study, administrators were defined as the immediate supervisors of teachers and the direct overseer of the STEM Strand in the school. Due to the different organizational structure of HEIs, private schools as well as the typology of DepEd stand-alone and integrated schools (small, medium, large, very large), different names were called for this position such as principal, assistant principal, SHS focal person, and STEM Strand Coordinator. With these qualifying experiences of teachers and administrators, the richness and broadness of the data obtained through interviews were ensured.

In addition, another type of sampling known as theoretical sampling was applied as the study progressed. Theoretical sampling is defined as “a procedure of selecting additional cases to be studied to gather new insights or expand and refine concepts already gained” (Taylor & Bogdan, 1998 as cited in Kolb, 2012). The researcher selected participants purposely and systematically at the early part of the study, but as the data analysis was conducted, theoretical sampling was used to enrich the emerging concepts and ensure that the best participants contributed to the development of the framework. This is in consonance to the study of Moser and Korstjens (2018) that the “grounded theory usually starts with purposive sampling and later uses theoretical sampling to select participants who can best contribute to the developing theory” (p. 11). At the start, major considerations for the teacher-participant must only be teaching science or mathematics in STEM Strand for three years or more while the administrator should be in the position for a minimum of three years. But after the six participants were interviewed, the



Philippine Normal University National Center for Teacher Education

researcher continued with theoretical sampling for the selection of teacher-participant based on length of teaching experiences aside from their teaching experience at STEM Strand, subjects handled (e.g. Biology, Mathematics, Physics, Chemistry, Research), highest educational attainment, non-education degree holders, and alignment of the subjects handled to their specialization or expertise. For administrators, theoretical sampling was done based on the relationship of the educational attainment to the STEM Strand, length of administrative experiences, and length of teaching experience before being an administrator. Thus, the employment of theoretical sampling contributed to the saturation of the development of categories and ensured that the framework developed is grounded in the data.

Tables 4 and 5 show the profile of participants who participated in the study.



Table 4. Individual profile of interviewed teacher-participants.

Pseudo-nym	Sex	Age	Highest educational Attainment	Length in years of teaching experience (over-all)	Length in years of teaching experience in STEM Strand	Specialization	Subject/s handled in STEM Strand
Flor	F	28	MS Biology Education	7	4	Biology	General Biology 1 and 2
X	M	40	MA Science Education major in Physics	10	3	Physics	General Physics 1 and 2
Michael	M	26	MA Science Education major in Integrated Science (with units)	3	3	Chemistry	General Physics 1 and 2; General Chemistry 1 and 2; Media and Information Literacy
Jordz	M	41	PhD Mathematics Education (with units)	19	4	Mathematics	Basic Calculus, Pre-Calculus
DeoGirl	F	59	MA Education major in General Science	35	4	Biology	General Biology 1 and 2, Earth Science
Pooh	F	41	MSIT major in Computer Education	10	4	Information Technology	Robotics
Cza	F	26	BSEd major in Mathematics	5	3	Math	Basic Calculus, Pre-Calculus, Statistics, Physics 1 and 2, Biology 1 and 2
Maestro	M	33	BSEd major in General Science	12	3	General Science	Earth Science, General Chemistry 1 and 2
Alfred	M	32	BS Nursing	8	4	Biology	General Biology 1 and 2
Joe	M	33	PhD Development Education	11	4	Chemistry	Practical Research 1 and 2, Chemistry
Bart	M	25	MA Science Education major in Physics	4	4	Physics	Earth Science, General Physics 1 and 2



Table 5. Individual profile of interviewed STEM administrators

Pseudonym	Sex	Age	Highest educational Attainment	Position in SHS STEM Strand	Length in years of Teaching Experience (over-all)	Length in years of administrative or supervisory experience	Length in years of administrative or supervisory experience in STEM Strand
Rina	F	37	PhD Science Education (with units)	STEM Subject Group Head	20	8	3
Armier	F	42	PhD Literature – English Stream	Principal	21	5	4
Jam	F	31	PhD Science Education (with units)	Focal Person	10	3	3
Airam Berns	F	54	MA in Language Teaching (with units)	SHS Coordinator	33	10	4
Lars	M	33	PhD Development Education	Assistant Principal	13	7	3
Will	M	41	MS Chemistry Education (with units)	STEM Subject Group Head	20	6	3
Chard	M	39	MAT Mathematics	STEM Coordinator	17	10	3
Shalom	M	30	PhD Science Education	Principal	9	4	3
Sensei	F	25	MAT major in General Science and Technology (with units)	SHS Coordinator	5	3	3
Jed	M	29	BSEd major in Biology	STEM Coordinator	9	6	4
Spiderwoman	F	38	MAEd major in Educational Leadership and Management	Focal Person	13	6	3



Procedures

In developing the procedural component of the study, three phases or stages aligned with the research questions were followed, to wit: Phase 1 - Analysis; Phase 2- Framework Development and Validation (Experts' content validation); and Phase 3- Development and Validation of Training Design and Indicators and Standards. Figure 11 shows the schematic diagram of the methodology followed in the study. Each phase of the study was observed with the intended deliverables as shown in Table 6.

Table 6. Intended deliverables in each phase of the study

Stage/ Phase	Intended deliverables
Analysis	A report on the construct and needs of SHS STEM Strand on the lens of the administrator and teachers
Framework Development and Validation	Validated Framework
Development and Validation of Training Design and Indicators and Standards	Validated Training Design; A set of validated indicators and standards

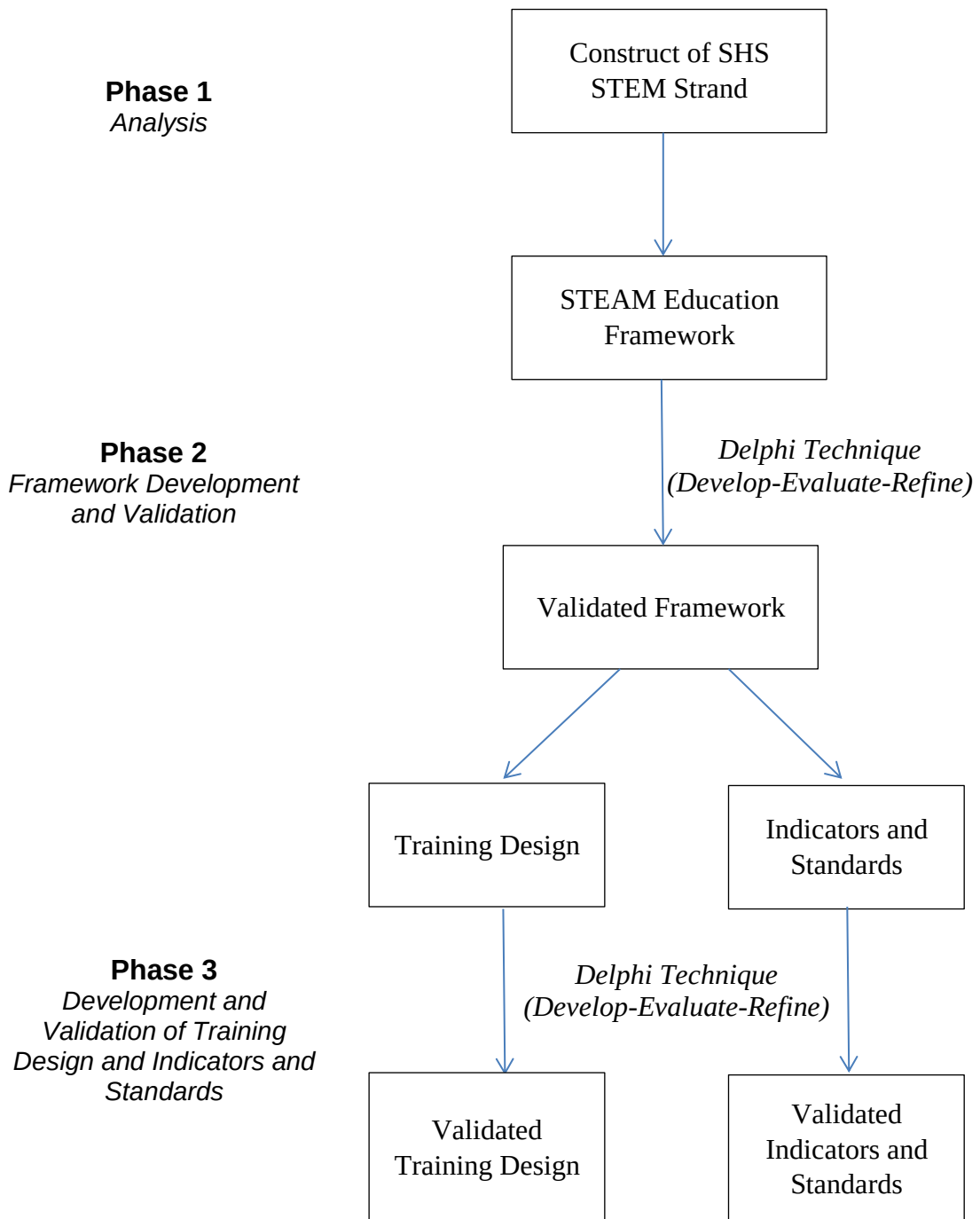


Figure 11. Schematic diagram of the methodology of the study.



Philippine Normal University National Center for Teacher Education

Before the conduct of the study, the researcher sought the approval of the Philippine Normal University (PNU) Research Ethics Committee (Appendix C). Upon approval of the ethics committee, a letter of request (Appendix D) for the list of public and private senior high schools offering STEM strand in Nueva Ecija and approval to conduct the study were secured from the Department of Education Region III Office. However, the regional office did not approve the letter right away due to the changes in requirements on conducting research in the region because of the COVID19 pandemic (Appendix E). To satisfy this, requirements were submitted immediately adhering to the DepEd Region 3 Memorandum No. 228 s. 2020 titled *Policy Guidelines on the Adherence to Ethical Research Principles and Responsibilities in Studies Involving Teaching, Teaching-Related, Non-Teaching Personnel and Learners* released on August 12, 2020 (Appendix F). These requirements include (a) Endorsement from the College/University (Appendix G), (b) Copy of Approval of the College/University Research Ethics Review Committee, (c) Instruments such as validation tools and interview guide, (d) Copy of Data Collection, Security, Storage, Transfer, Destruction Procedures, (e) Informed Consent Form, and (f) Informed Consent Form for Recording Interview. Afterwards, the Regional Director approved the letter request and provided the researcher with the list of DepEd Senior High Schools offering STEM Strand (Appendix H). The endorsement regarding the approval of the study was also sent to the respective Schools Division Superintendent (SDS) for each division school in Nueva Ecija. For the list of HEIs with SHS STEM Strand, the researcher conducted a preliminary survey to



Philippine Normal University National Center for Teacher Education

determine the number of HEIs offering senior high school with STEM Strand since there is only a limited number of HEIs in Nueva Ecija.

After selecting participating schools for each classification of SHS through fishbowl technique or lottery random sampling, a pilot survey on each school was conducted to determine the names of the teacher and administrators for the study. Letters to allow teachers and STEM Strand administrators in the selected schools to participate in the study were given to the respective school principals (Appendix I) and the respective president of HEIs (Appendix J). Upon endorsement of the individual school principal and President of HEIs, letters of request for the teacher-participants (Appendix K) and administrators (Appendix L) to be part of the study were distributed. Along with this letter is the informed consent form (Appendix M). The letters were given in batches in accordance with the theoretical sampling employed in the study. The participants were given a timeframe to return the signed informed consent form and fortunately, all the participants who were given the letter agreed to participate in the study. Ten teachers and ten administrators including an additional pair of participants (one teacher and one administrator) for data saturation took part in the study. While waiting for the approval of the DepEd Region III Office, the aide memoires or interview guides used in the study underwent face validation from the adviser of the researcher with the panel of validators.

Phase 1: Analysis

This is the most important phase since the other phases of the study took flesh on this stage. In this phase, a qualitative approach was selected rather than a quantitative



Philippine Normal University National Center for Teacher Education

approach (survey method) because of the holistic nature of qualitative research. As explained by Creswell (2007), the qualitative approach is more appropriate in studies like creating a sketch of a larger picture that emerges from the situation, understanding the various factors of a situation, and identifying intricate interactions of different factors in the situation. Moreover, qualitative approaches are used when a researcher wants to understand the participants' different perceptions and viewpoints toward a topic.

To generate a construct of the SHS STEM Strand wherein needs were evaluated from the perspectives of teachers and administrators, a grounded theory approach was used. Often, the grounded theory approach is utilized by different researchers when there is only a little information known about the topic or the subject area (Adolph, Kruchten, & Hall, 2011; Buenk, Grobbelaar, & Meyer, 2019; Morse 1994). Considering that the SHS STEM Strand is relatively young and there are limited studies conducted on STEM strand and the STEAM education in the Philippines, the grounded theory approach is fitted as the best method in the analysis phase of the study.

Development of the Interview Guide

In this study, a semi-structured interview was utilized. A semi-structured approach in the interviews provides flexibility in asking questions and entails an easy comparison of the themes that emerge from the different interviews for the researchers (Hendrick, 2013). In healthcare studies using the grounded theory approach, the most commonly applied method is semi-structured interviews (Foley & Timonen, 2015). Furthermore, semi-structured interviews let the researchers use their prior knowledge



Philippine Normal University National Center for Teacher Education

during the interview process (Rose, 1994). As Duffy, Ferguson, and Watson (2004, p. 69) stated, “the use of semi-structured interviews is therefore congruent with grounded theory methodology as it allows the researcher to ask key questions in the same way each time, but allows flexibility in the sequencing of questions and the depth of exploration.”

For this study, questions were carefully crafted to determine the perspective of teachers and administrators in terms of various factors in STEM Strand including but not limited to the pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, and institutional support. Some questions were adapted from the study of Morales and colleagues (2018). Furthermore, the questions constructed were open-ended to promote continuous discussions of the researchers and participants. Moreover, the crafted questions for the teachers were aligned with that of the administrators (Tables 7 and 8).

Table 7. Interview questions for STEM teachers

Concept	Interview Questions
<i>Pedagogical Traits and Characters</i>	What do you think are your characteristics that qualify you to teach in the STEM Strand? a. How do you maintain your reputation as a good STEM teacher?
<i>Curriculum</i>	What do you think of the STEM curriculum and design? a. Do you think the curriculum is comprehensive enough for the students? b. Why do you think so?
<i>Instruction and Delivery</i>	On a scale of 1 to 10, how do you rate your overall knowledge in the STEM Subjects?



Philippine Normal University
National Center for Teacher Education

	a. Why do you say so? Do you think you have sufficient preparation (in terms of technological, pedagogical, and content) to teach STEM subjects? a. Why or why not? What other fields do you think are necessary in learning and teaching STEM? a. How do you rate your content knowledge in each of these fields? How do you promote innovative, active, engaging, and collaborative learning in the class? a. How about reflective and critical thinking? b. How do you structure your teaching activities in STEM? Do you find the STEM subjects difficult or problematic in any way? a. Why do you think so?
<i>Feedback System</i>	How do you assess your students? a. What are your criteria in the selection of assessment tools? How did you establish students' consultation in class?
<i>Learning Environment</i>	Learning environment is an important aspect in teaching. a. How do you promote and maintain safe learning environment in school? b. How do you effectively manage your students during class?
<i>Institutional Support</i>	What support mechanisms have you received from your institution for your teaching? If you were an administrator, what support would you give to your teachers?
<i>STEM Strand</i>	What can you say about the SHS STEM Strand in general? a. How would you describe your overall teaching experience



	in STEM Strand? b. If you could improve or change any aspect of STEM Strand, what would it be and why?

Table 8. Interview questions for administrators

Concept	Interview Questions
<i>Pedagogical Traits and Characters</i>	What are the characteristics that your teachers must possess in order to teach in STEM Strand? a. Why do you say so? b. What are your indicators that a teacher is a good STEM teacher?
<i>Curriculum</i>	What do you think of the STEM curriculum and design? a. Do you think the curriculum is comprehensive enough for the teachers and students? b. Why do you think so?
<i>Instruction and Delivery</i>	Do you think your teachers have sufficient preparation (in terms of technical, pedagogical, and content) to teach STEM subjects? a. Why or why not? What other fields do you think are necessary in learning and teaching STEM? a. How do you rate your teachers' content knowledge in each of these fields? How do you help your teachers in promoting active, engaging, and collaborative learning in the class? a. How about in reflective and critical thinking? Do you think your teachers find the STEM subjects difficult or



Philippine Normal University
National Center for Teacher Education

	problematic in any way? a. Why do you think so? On a scale of 1 to 10, how do you rate your teachers' overall knowledge in the STEM Subjects? a. Why do you say so?
<i>Feedback System</i>	How do you manage/handle your teachers? a. What arrangement or structure do you adopt in using the assessment and feedback system for the improvement of the curriculum and practice? b. What do you think are the weaknesses and strengths of this system?
<i>Learning Environment</i>	Learning environment is an important aspect in teaching. a. How do you ensure and promote a safe learning environment in your school? b. How do you monitor your teachers' classroom management?
<i>Institutional Support</i>	What are the support mechanisms that you give to your teachers? a. How do you encourage your teachers to attend training related to but not limited to contextualization, collaborative learning, and assessment? b. Do you think the teachers received support well from the school? c. Why do you say so?
<i>STEM Strand</i>	What can you say about the SHS STEM Strand in general? a. How will you describe your overall administrative experience in the STEM Strand? b. If you could improve or change any aspect of the STEM Strand, what would it be and why?



Philippine Normal University National Center for Teacher Education

The developed interview guides/aide memoires were checked by a language expert and subjected to validation by the researcher's adviser and a panel of experts. A PNU PhD Science Education degree holder, a DLSU PhD in Educational Psychology degree holder, an SHS STEM Teacher, and an SHS STEM administrator constituted the panel of validators for the aide memoires (see validator's profile in Appendix N). They were given a letter requesting their expertise and assistance in validating the aide memoires for teachers and administrators (Appendix O). Attached in the letter is the aide memoire validation instrument wherein the appropriateness of the aide memoire in terms of grammar, clarity, spelling of words, the structure of sentences, and sequencing of interview questions were asked to be assessed. The validation instrument also includes questions on the completeness of the interview guide and that elicit suggestions, comments, and insights from the validators (Appendix P). From their comments, the aide memoires were revised (see sample comments in Figure 12) (Appendix Q). Then, the revised aide memoires were pilot tested on a different set of STEM teachers and administrators to determine the appropriateness and clarity of questions, the length of the interview, and if the questions were engaging. The pilot try-out interview for the teacher lasted for 67 minutes while the interview lasted for 77 minutes for the administrator. The feedback generated from the try-out was used for the further refinement and revision of the interview guide and interview questions. The final revised aide memoires for teachers and administrators (Appendices R and S) after validation and try-out were used in the interview of the participants.



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Taft Avenue, Manila

Validation Instrument for the Aide Memoire

Name: [REDACTED]

Date: August 21, 2020

After reading the interview questions and the objectives of the study, please kindly answer the following questions.

1. Are all the aide memoire appropriate in grammar, clear and unambiguous? Do they adhere to correct spelling of words, and correct structuring of sentences? If not, kindly elaborate.

Questions found in the aide memoire, designed for teachers and administrators, adhere with correct rules of grammar and syntax.

2. Does the sequencing of the interview questions logical? If not, kindly elaborate.

Interview questions are logically sequenced, however, I suggest that each concept be crafted with main question. The main question must have probing questions.

3. Are the interview questions complete? If not, what do you think should be added in the questions?

Formulated aide memoire, to my belief, is already complete but consider refinement in some items. Please see suggestions in No. 4.

4. Do you have any suggestions or comments for the improvement of the aide memoire? Please provide the details.

The following are my suggestions for improvement of the interview guide:

- **It is suggested that each concept be crafted with a main question. Existing questions may be retained as probing question or maybe considered/elevated as a main question.**
- **In all instances, please avoid double-barreled questions** (please see/review Aide Memoire for Administrators, Instruction and Delivery letter *c*; Feedback mechanism letter *b*; STEM Strand letter *a*).
- **Please refrain from asking leading question. For example, instead of asking the question, "How about reflective and critical thinking?" re-think of a question where the concept reflective and critical thinking will be drawn from the teachers.**
- **For the Aide Memoire for Administrators, kindly consider: What do you think are the characteristics that your teachers must POSSESS in teaching in STEM Strand?**
- **For the Aide Memoire for Administrators, under Instruction and Deliver (can be phrased as Instructional Delivery), question *a* can be asked last.**
- **For the Aide Memoire for Teachers, under Institutional Support, phrase the question in a tone as support from the institution not support from principal.**

[REDACTED]

Signature of the validator

Figure 12. Sample comment of a validator for the aide memoire



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Data Collection

All the interviews were conducted using online platforms based on the participants' choice. Other platforms such as Facebook Messenger Room, Discord, Skype and Viber were not included in the choices since these applications have limited features for recording options. Many participants chose video conferencing platforms such as Zoom and Google meet, but some also chose Cisco WebEx and Microsoft Teams (MS Teams) as their platforms for interviews (Table 9). The researcher let the participants decide on the date and time they would be interviewed for convenience. It was noted, however, that the majority of the participants selected 7-10 pm as their time of the interview. Many answered that such a time slot is ideal when asked for their reason because their household duties and online classes are already done. To assure the privacy of the interview, the researcher enabled the "waiting room" features of the Zoom and MS Teams. This was also made to ensure that no one could abruptly enter videoconferencing applications which may compromise the interview and its confidentiality. For Google Meet and Cisco WebEx, the option that only the host of the meeting could accept the participants on the platform was activated. To add more protection, the link was given on an invitation basis only and all entries to the online meeting rooms were password-protected. The researcher also requested participants to find a quiet place to minimize disturbances, disruptions, and noises that might affect the participants' focus on the interview.



Philippine Normal University National Center for Teacher Education

During the interview, the researcher explained first the background information and the goals of the study. The information in the consent form was discussed again by the researchers for clarity and better understanding. They were informed why they were selected for the study and the risks and benefits of their participation. Also mentioned were the activities for their involvement and that their information would remain confidential. Their option to withdraw at any time or their refusal to participate was also elaborated. The researcher explained to them that withdrawal would not affect them in any way and if they do withdraw, they may request that their data be destroyed or deleted unless a de-identifiable state is in place. They were also made aware that the interview may take one hour or more depending on the discourse of the interviewee and the researcher.

Also, before recording the interview, the participants were given an informed consent form for video- or audio-recording and transcription (Appendix T). In this consent form, it was explained that neither identifying information nor their name would be associated with the audio or video recording or the transcript and that the recordings will be stored in the google drive of the researcher which is password protected and encrypted. It was also mentioned that their recording would be listened to and transcribed solely by the researcher and that these would be deleted once the transcriptions were checked for accuracy. Furthermore, the form detailed on the reproduction of transcript in part or in whole for use in presentation and written products such as in research journals, but only pseudonyms of their choice will be used.



Philippine Normal University National Center for Teacher Education

After the explanation of the rigors of the study, interview questions were carefully delivered to avoid any bias regarding their perception and construct of the STEM Strand. They were asked general questions like (1) *What can you say about the SHS STEM Strand?* (2) *What do you think of its curriculum and design?* among others following the guide questions in aide memoires. Through these questions, the researcher made the teachers and administrators play the role of a discussant in which they were free to say all they wanted about the SHS STEM Strand. They were also informed that they can answer in English or Filipino whatever is convenient to them to have a better response from the participants. Probing questions such as (1) *Please tell me more about that,* (2) *What else you can say?*, and (3) *“Anything you want to add?”* were also asked to extract more information from their responses and to elicit elaborated answers. However, the sequencing of the questions in the aide memoires was not followed most of the time since during the interview, participants were able to mention some interesting topic about the STEM Strand that the researcher let the interviewee explain continuously rather than disrupt them since the idea may be lost or forgotten if interrupted. Also, during the first questions, some interviewees tackled already the proceeding questions that the researcher just allowed them at utmost flexibility. Some questions were also made on the spot to expound on the salient construct or point about the STEM Strand given by the interviewee. Moreover, questions were added focusing on the emerging concepts especially on the participants selected from theoretical sampling. For two interviewees, the researcher determined that the interview data needed more elaboration thus, follow-up interviews were conducted.



Philippine Normal University National Center for Teacher Education

Throughout the interview, the researcher speaks and listens with utmost mindfulness to the interviewee's feelings throughout the conversation. When the researcher felt that the interviewee had hesitation, showed unwillingness, or felt discomfort in answering, other questions were quickly asked concerning the interviewee's well-being. When the interviewee went off track with the topic, the researcher politely brought them back to the question at hand. Interview techniques such as echoing, mirroring, and summarizing ideas were employed to encourage them to speak more and indicate that the researcher understood what they said. The researcher ended the individual interview when the participant had already given the same information or answer even after probing questions. The interview took 58 to 108 minutes that depended on the discourse of the participant and researcher (Table 9). Additional participants were interviewed to confirm that data saturation was met, where there is a redundancy of the data and no new emerging concept in the last interview was noted. To ensure confidentiality, a pseudonym for participants was used. The interview was recorded through the recording options of the online platform as per participants' consent.



Table 9. Frame of the conducted interview

Participant	Position	Duration (in minutes)	Platform used
Rina	STEM Subject Group Head	108	Google Meet
Flor	Biology Teacher	71	Zoom
Armier	Principal	62	Google Meet
X	Physics Teacher	65	Google Meet
Jam	Focal Person	98	Microsoft Teams
Michael	Chemistry Teacher	58	Zoom
Airam Berns	SHS Coordinator	89	Zoom
Jordz	Mathematics Teacher	63	Google Meet
Lars	Assistant Principal	73	Google Meet
DeoGirl	Biology Teacher	65	Google Meet
Will	STEM Subject Group Head	67	Google Meet
Pooh	Robotics Teacher	63	Microsoft Teams
Chad	STEM Strand Coordinator	81	Google Meet
Cza	Mathematics Teacher	68	Zoom
Shalom	Principal	72	Google Meet
Maestro	General Science Teacher	63	Zoom
Sensei	SHS Coordinator	71	Google Meet
Alfred	Biology Teacher	70	Cisco WebEx
Jed	STEM Strand Coordinator	68	Google Meet
Joe	Chemistry Teacher	71	Zoom
Spiderwoman	Focal Person	77	Google Meet
Bart	Physics Teacher	68	Zoom



Philippine Normal University National Center for Teacher Education

Field Notes, Case Summary, and Memoing

Field notes, memoing, and case summary through contact summary form were done to facilitate the qualitative analysis and to have a detailed and extensive data collection. Glaser (1998) explained that grounded theory is more on the “discovery of underlying social process” centered on exposing the picture of what is really happening regarding a specific matter or topic and how it is handled in the field. In this context, field notes, case summary, and memoing in addition to audio/video recordings and transcription were found essential in producing a richer account of the teachers’ and administrators’ construct on STEM Strand, which later informed the development of STEAM Education Framework.

Field note is defined as “a freely written chronicle of the researcher’s observations of events and interactions during data collection” (Montgomery & Bailey, 2007, p. 70). Many authors contend that the field notes written are generally scribbled, unclear, and sketchy but could be transformed into an intelligent write-up after a thorough and careful process that could be used to explain and better understand the data. Mostly, field notes contain introductory insights and evolving preconceived ideas, thus, a detailed narrative of methodological, descriptive, and analytic information is produced.

In writing the field notes, the researcher carefully selected the details that were included by only writing transcription and inscription from the interviewee. The description of the activities and events (inscription) and the records of the interviewee’s important words and dialogues (transcription) as well as the researchers’ own ideas were



put into minimum during the interview to prevent distraction/interruption on the part of the interviewee while speaking because of the researcher's note-taking. This was maintained throughout the interview to ensure that the discourse of the researcher and the interviewee was fluid. However, elaboration of the details was done immediately after the interview so that the recollection of the interview and ideas was still vivid. Also, the audio/video recordings were reviewed to enrich the field notes. Further, to distinguish the researchers' actions, questions, and reflections during each interview, the researcher separated it by placing a box on the side (see figure 13) (Appendix U).

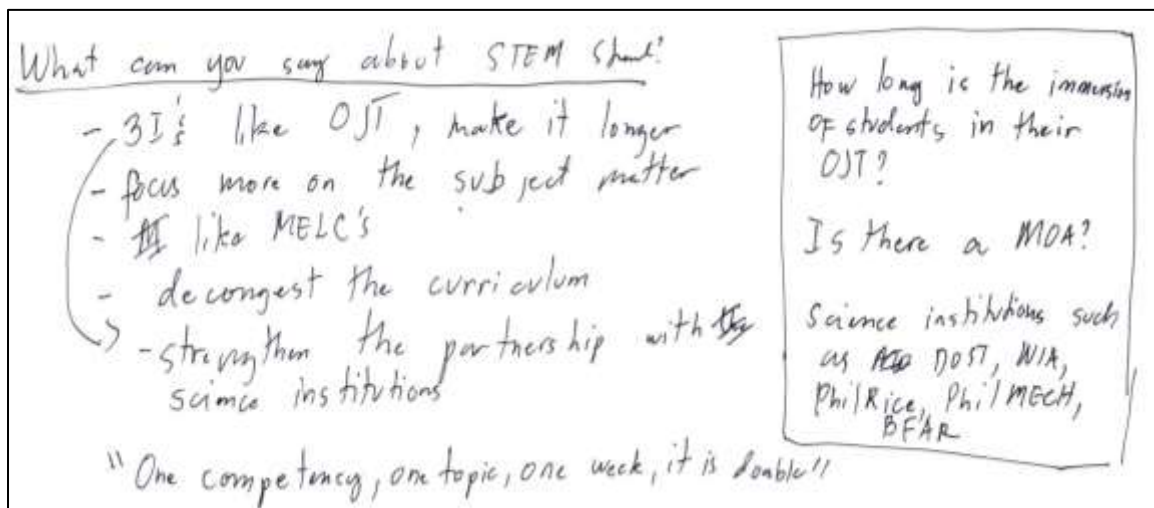


Figure 13. Sample field notes wherein researcher's ideas were placed on a box to separate from the interviewees' insight of STEM Strand

After accomplishing the field notes, a case summary was prepared for each participant. The case summary provides the essential information and other special or peculiar things in the interview conducted. It familiarizes and allows the researcher to



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generalize the issues and themes generated and then compare them with other interviews' results. The case summary of each participant was written in a contact summary sheet, a form used to remember the main concepts, issues, themes, and questions raised during the interview and review the field notes and make comments. Also, a case summary sheet was utilized to ascertain the areas, subjects, or topics focused on in the next interview. Furthermore, it served as a reminder when the interview was conducted and served as a basis for planning the following interview and data analysis.

As patterned in Miles and Huberman (1994), the sheet contains primarily the information where the interview was done, the date of contact, the date when the sheet was accomplished, the hunches, hypotheses, and speculations provided by the interviewee, and the main issues, central questions, and themes that the interviewee focused on (Appendix V). The contact summary sheet was filled out after the field notes were written but not too soon to avoid bias from the researcher (see sample in Figure 14). All contact summary sheets were done one day after the field notes were completed and before the following interview. Thus, the interview was scheduled with two to three-day intervals from one participant to the next to give the researcher enough time to make the field notes and contact summary sheet. The sheet was used as a guide for follow-up interviews from the two participants for further clarification. Contact summary sheets were also linked to the field notes for easy reference and interpretation.



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National Center for Teacher Education

CONTACT SUMMARY SHEET	
Name: <u>_____</u>	Date of interview: <u>November 27, 2020</u>
Pseudonym: <u>Jordz</u>	Time: <u>2:05 pm</u>
Position: ☒ Teacher	Date of accomplishing this form: <u>November 29, 2020</u>
☐ Administrator	
Type of SHS:	Modality of Contact: ☒ google meet
☐ Public Integrated JHS – SHS	☐ zoom
☐ Public Stand alone SHS	☐ face to face
☐ Private SHS	☐ others pls specify:
☒ HEI with SHS	
☐ Private HEI with SHS	
1. Main issues/themes/concepts given by the contact helpful in the study	
a. <u>STEM curriculum design is comprehensive but congested</u>	
b. <u>STEM Strand is helpful in preparing the students for courses in STEM fields</u>	
c. <u>Support and training for STEM Teachers are still lacking</u>	
d. <u>Alignment of the subjects taken in junior high school with that of senior high school must be studied.</u>	
2. Summary of information obtained (or not) on each of the questions	
a. <u>Teacher of STEM Strand should have good educational background, have passion, vision, and dedication.</u>	
b. <u>There are too many topics to be tackled for his subject</u>	
c. <u>Limited knowledge and skills on technology integration</u>	
d. <u>Critical thinking and problem-solving skills are instilled to the students of STEM Strand</u>	
e. <u>In terms of assessment, he is more on traditional and collaborative.</u>	
f. <u>STEM Students are matured enough.</u>	
3. Any other salient, illuminating, interesting, or important points	
a. <u>Some STEM students take other courses not related in STEM field such as accountancy</u>	
b. <u>He claims that he still lacking in researches in mathematics education</u>	
4. New or remaining target questions for next contact	
a. <u>How limited knowledge/skill/training on research in their own expertise affects teachers or administrators of STEM Strand?</u>	
5. Other Concern/s:	
<u>None</u>	

Figure 14. Sample contact summary sheet

For the researcher's own thoughts, ideas, and insights, memoing was done. Memoing is typically a note for oneself and is most commonly associated with grounded



Philippine Normal University National Center for Teacher Education

research. Literally, memoes are the “documentation of the researcher’s ideas and thinking processes during data collection, analysis, and interpretation” (Montgomery & Bailey, 2007, p. 65). Memos were very helpful to the researcher in confirming the results and in building the STEAM Education Framework. As explained by Birks, Chapman, and Francis (2008), “the researchers are able to immerse themselves in the data, explore the meaning that this data holds, maintain continuity and sustain momentum in the conduct of research through the use of memos. As a chronicle of the research journey, memos remain as an indelible, yet flexible, record for personal retention or dissemination to others.” (p. 69). The use of memos established a strong relationship with the data, thus allowing the researcher to have a greater degree of engagement and to provide more meaning to the information contained in the data. If field notes’ primary role is to give description and visualization of the data collection in the study, memo, on the one hand, serves as an abstraction and interpretation of meaning from the field of study.

The memoing process lets the researcher think, decide and interpret while analyzing the data. These memos were done throughout the study until the end of data analysis. A stop-jot style of memoing was utilized in the study wherein memos were written in a dedicated notebook and always carried so that when a hypothesis, hunches, or reflections occurs, the researcher easily jot it down (Appendix W). This was given priority throughout the study such that all ideas relevant to the study were written down as soon as possible to avoid forgetting them and for the flash of insights to remain. The memos were used to question the quality of the interview and the themes generated during the analysis and were dated and categorized into four as proposed by Gibson



Philippine Normal University National Center for Teacher Education

(2012). The memos were marked according to the category: a) Observation Notes (ON) – about what the researcher saw, heard, etc.; b) Methodological notes (MN) – the researcher’s note about how to collect data, what to do during an interview, and all related about data collection; c) Theoretical notes (TN) – the hypothesis, hunches, connections, alternative interpretations, and critiquing of the researcher; and d) Personal Notes (PN) - the researchers’ feeling about the research such as doubts, anxieties, and pleasures (see samples in Appendix X). The methodological notes and theoretical notes were further categorized with the memoing techniques of Strauss and Cobin (2008) into code memo (notes while coding), theoretical memos (notes while doing axial and selective coding) and the operational memo (directions relating to the evolving research design). However, the categorization of the memos was only done after finishing the constant comparison method so that free and open pre-conceptual thinking process and intellectual creativity of the researcher were not stopped, distracted and complicated by categorizing them during data collection and analysis. The memos were also used to map the research activities. They were separated from the transcriptions, field notes, and contact summary sheet to distinguish the interviewee’s original comments from the researcher’s insights and conceptualizations.

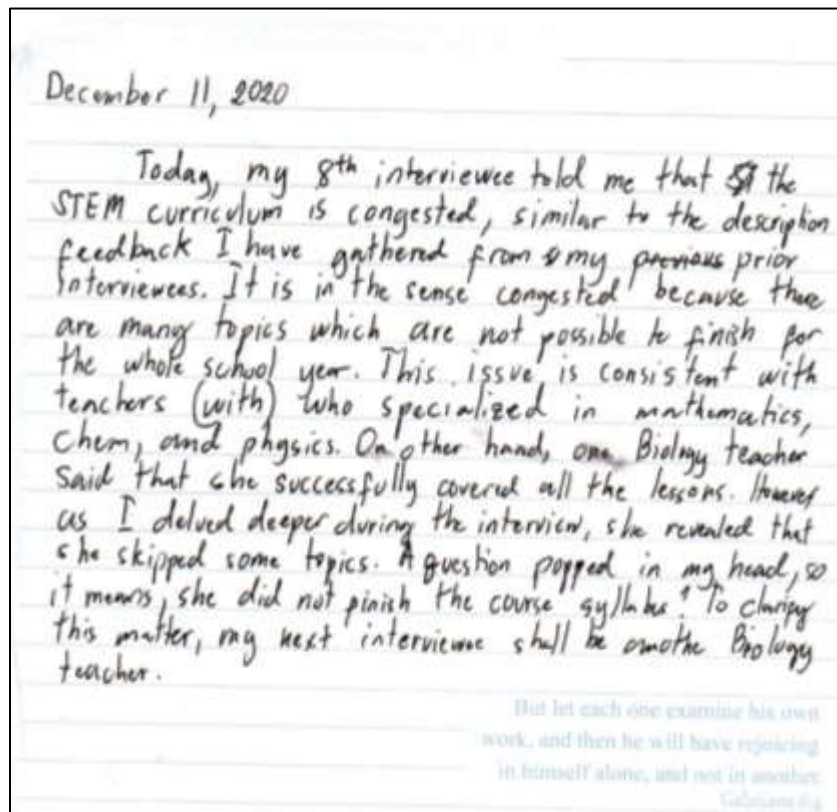


Figure 15. Sample Memo

Constant Comparison Method and Coding

After the interview of each participant, the recordings were transcribed and checked for accuracy. The responses in Filipino were translated into English (Appendix Y). A language expert reviewed the translation. To protect the identity of the participant during translation, all identifying information in the transcript was redacted. The transcribed and translated interview transcript was returned to the participants to check the veracity of information and to check if the information was correctly captured. All participants were asked if they wanted to add or change anything on the transcript. A



form was given to each of them and they were requested to affix their e-signature to affirm the veracity of the transcribed and translated interview (Appendix Z). Moreover, each page of the interview transcript was also asked to be signed by the participants.

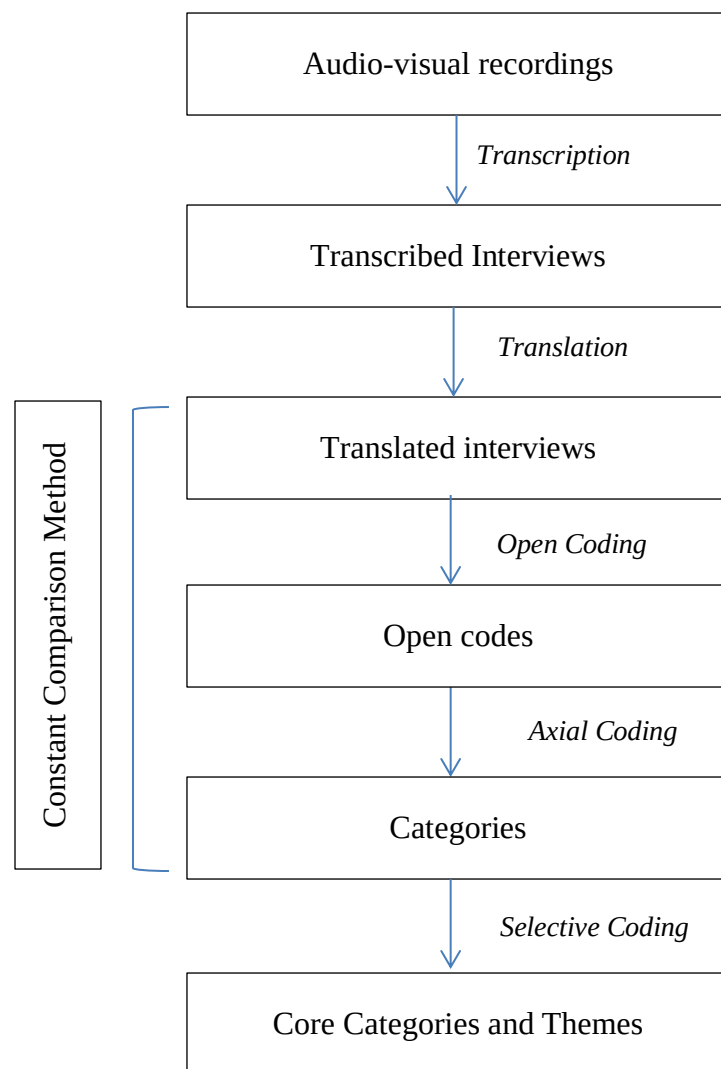


Figure 16. Constant comparison method and coding processes in the study



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Afterwards, interview data were coded in accordance with the proposed scheme of Strauss and Corbin (1998): open, axial, and selective coding. In addition, the constant comparison method, a concurrent data collection and analysis, was conducted along with the open and axial coding (Figure 16). The constant comparison method is an inductive, deductive, or abductive interweaving of data collection and analysis that generates and formulates strategies to enrich the data (Tie, Birks, & Francis, 2019). Many authors recommend the constant comparison technique as some qualitative researchers gather the data first and put their prime energy in it for months or years and then become demotivated and exhausted because of the enormous data to analyze. Many qualitative researchers are overwhelmed with data analysis when the constant comparison method is not used, hence, reduces the quality of the work and data (Miles & Huberman, 1994).

Using the constant comparison technique, the researcher identified the incidents or codes in the first data collected or generated (open coding). In preparation for coding, the interview transcript was printed in a single space format on the left side page of the paper keeping a wide margin on the right side for writing codes and notes.

The interview transcripts were prepared in a poem-like or verse-like format for easy reading and analysis (Figure 17). Manual coding through highlighters, different colors of pen, and pencil was done to have a hands-on abstraction and familiarization of the data (Appendix AA). Afterwards, these codes and reference texts were transferred in an electronic file through the Contact Summary Sheet for Coding (Appendix AB). The interview transcript was read several times for selecting initial relevant texts and tentative labels for the information (open codes) were constructed. Salient topics, a pattern of



Philippine Normal University National Center for Teacher Education

beliefs, recurring words or ideas were identified through this process. Coding techniques such as descriptive coding (summarizing primary topic in the text), process coding (using an action word or phrase to describe the text, the researcher used gerund in this type of coding), in vivo coding (using codes derived from the exact word or phrase of interviewee), and simultaneous coding (two or more codes were noted in a single datum) were used to produce the codes. These coding techniques were patterned from Saldana (2014). A codebook containing the codes, description, and examples was also written to keep track of the codes generated as it is hard to remember all the codes and to have consistency during the coding process.

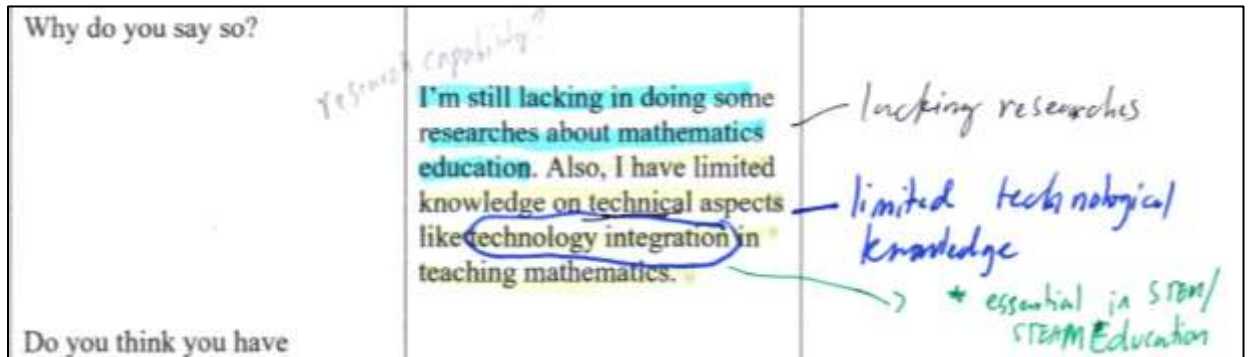


Figure 17. Sample coded interview transcript

In each code, incident to incident was compared using the contact summary sheet for coding. In the same transcript, open codes were compared to the other codes. Using the axial coding process, the number of open codes was reduced and relationships among them were identified by formulating different categories (Appendix AC). After each



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National Center for Teacher Education

interview, open and axial coding of the transcript was done. The subsequent codes and categories that emerged from the participants were compared, sorted and contrasted with the previous ones using the contact summary sheet for coding (Figure 18). This was repeated until data saturation was met where no new code and category was formed or emerged from the participant.

Contact Summary Form (for Constant Comparison)		
Name: _____	Date of interview: December 11, 2020	
Pseudonym: Armier	Time: 7:31 pm	
Position: Teacher	Date of Transcription: December 13, 2020	
☒ Administrator		
Type of SHS:	Modality of Contact: ☒ google meet	
_____ Public Integrated JHS – SHS	_____ zoom	
_____ Public Stand alone SHS	_____ face to face	
_____ Private SHS	_____ others pls specify:	
☒ HEI with SHS		
_____ Private HEI with SHS		
Date Coded: December 14, 2020		
Note: Pick out the most salient points in the interviewee. Number in order on this sheet and note page number on which the salient point appears. Number point in text of write-up. Attach theme or aspect or code to each point in CAPITALS. Invent themes where no existing ones apply and asterisk those. Comment may also be included in double parentheses.		
Page	Salient Point	Themes/Aspects/Codes
3	They must be graduate of science courses so that they can deliver the content. That should be the basic requirement. And if a teacher is a graduate of science course, we can expect him or her to be inclined with science teaching so everything follows.	BACKGROUND IN SCIENCE
3-4	Like enthusiasm, motivation to teach the course, and probably the passion, love for the subject. Those must be inherent to the teacher.	INNATE TEACHER'S CHARACTERISTICS
4	I really honor the parameters being used by the students when it comes to the performance of the teachers because they themselves are the end users of whatever engagement the teacher is doing in the classroom with them so I believe they are the best people to say whether a teacher is performing well or not.	GOOD TEACHER PERFORMANCE EVALUATION

Figure 18. Sample Contact Summary Sheet for Coding



Philippine Normal University National Center for Teacher Education

After the sixth interview, theoretical sampling was done to enrich the emerging categories. As Hull (2013) stated, “By theoretical sampling, the researcher is looking for specific concepts to examine how they might vary under different conditions” (p. 23). These varying conditions were explored in the study by conducting interviews in teacher-participants with differing subjects handled (e.g. Mathematics, Biology, Chemistry, Mathematics, Physics, and Research), with differing highest educational attainment (BS, MA, PhD), and with non-education degree (e.g. graduate of BS Biology). Also, theoretical sampling was done for teacher-participants based on length of teaching experiences aside from their teaching experience at STEM Strand and based on the alignment of their subjects handled with their specialization (e.g. a teacher graduate of Bachelor of Secondary Education major in biology but teaching Chemistry in STEM Strand). For administrators, theoretical sampling was done based on the relationship of the highest educational statement to the STEM Strand, length of administrative experiences, and length of teaching experience before being an administrator. In this manner, theoretical sampling contributed to the saturation of the development of categories and helped in the grounding of data for the framework developed.

To the best knowledge of the researcher and through the memos, the data saturation was met on the 16th participant interviewed. The remaining four participants were still interviewed and an additional set of STEM teachers and administrators were added to confirm the data saturation. Through these processes, refining of concepts (codes) and relevant categories was achieved. The constant comparative method iterations helped the researcher easily track and identify the new categories and codes



Philippine Normal University National Center for Teacher Education

that appeared different from the earlier data. Abductive reasoning, along with inductive and deductive thinking, was also used by the researcher to generate the codes, categories and theories. Abductive reasoning is defined as “a form of reasoning that begins with an examination of the data and the formation of a number of hypotheses that are then proved or disproved during the process of analysis which aids the inductive conceptualization” (Tie, Birks, & Francis, 2019, p. 4).

After the constant comparison method in open coding and axial coding, all interview transcripts, memos, field notes, and contact summary sheets were re-read. Matrices of participants' answers for each question were prepared for easy comparison, organized reading, and better recoding of the data corpus using color scheme (Figure 19). In this process, some open and axial codes were sorted, grouped, recoded or regrouped. Some categories were also refined and recategorized for clarity and better understanding. Further, data corpus in the interview that was initially not included as the relevant text was reviewed and analyzed for possible inclusion in the codes and categories. These were done comprehensively so that no data or portions were deleted or disregarded, which may contain essential information that may affect the framework generated. Other data corpus excluded in the first open and axial coding were linked to other codes and categories to account for all data.



what are the characteristics that your teachers must possess in order to teach in STEM Strand? Why do you say so? What do you think are your characteristics that qualify you to teach in the STEM Strand?		
My flexibility. I think, to teach any areas in science and as well in research	Teachers in the STEM Strand should have their specialization aligned with the aforementioned strand; meaning, they should have the right set of skills to deepen the learner's potential and abilities. Also, a STEM teacher should be a mentor, a guide who encourages his or her learners in active participation, gets them into a situation to face problems independently and finding resolutions on the spot. Further, he or she must set the standards and must understand but is firm in his or her decisions in right direction. To ensure that knowledge and skills intake is successful, STEM teachers should be flexible, adept to different learning styles, can develop techniques for teaching such as using projected presentations, videos, and other high-end learning tools. STEM teachers must be knowledgeable and should remain an open book.	First is that I am passionate in teaching science. I also love science. Also I am curious in everything since this curiosity may also be imparted to the students. My willingness to engage in continuous development in this field through taking Master's Degree major in General Science so that I can be more competent.
As for my opinion, the things that qualify me to teach in the STEM Strand because academically speaking I am a graduate of Based major in Biological Sciences and way back in high school I am a graduate of a Science High School which brings out all the curiosity and traits that needs to be passed on to STEM students.	For me the characteristics that qualify me to teach in the STEM Strand is first, I engage students in learning. Second, because of my discipline which is mathematics that is important in STEM Strand. Last is that I have strong work ethic.	They must be graduate of science courses so that they can deliver the content. That should be the basic requirement. And if a teacher is a graduate of science course, we can expect him or her to be inclined with science teaching so everything follows. Like enthusiasm, motivation to teach the course, and probably the passion, love for the subject. Those must be inherent to the teacher.

Figure 19. Part of a matrix of participants' answers for each question

After these processes, selective coding ensued. In this process, core categories were identified, selected, and related to other categories. In this stage of the data analysis, the emergent categories were grouped, refined, and clustered under themes. To facilitate the construction of the initial framework, diagramming of Strauss and Corbin (1998) was utilized (Figure 20). A “storyline” of the categories was drafted through diagramming which started during the axial coding. Strauss and Corbin (1998) used diagramming extensively in their analysis as they treat it as the center of the coding processes. Through flowcharts, drawing, and action chains of integrated core categories, the STEAM Education framework was created.

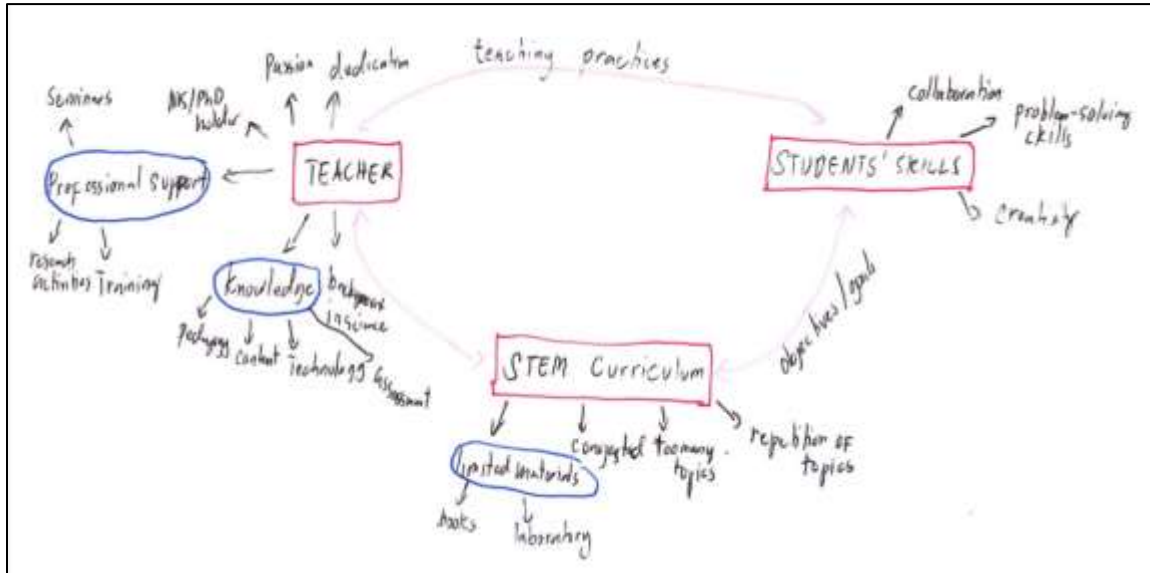


Figure 20. *The initial diagramming constructed in the study.*

Data Validation, Reliability, and Researcher's Bias

To ensure validity and reliability of the data generated, different precautionary measures were observed. Validity was assessed through member checking, triangulation, intercoding, and checking of researcher's bias. These processes were done to establish the veracity of the data gathered and of the data analysis.

Member checking is a validation technique focused on the accuracy and trustworthiness of the findings by sharing a brief or whole summary of the results to the research participants. As explained by O' Connor and Gibson (2003), "the best way to examine the validity of the research findings and of the researcher's interpretation of them is for the researcher to go back and ask those individuals who participated in the study or who can speak on behalf of them" (p. 74). In the study, member checking was



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done by letting the interviewed participants (two teachers and two administrators) examine the generated framework, categories and subcategories. They were asked if the result somewhat conformed to their experiences.

Another validation technique in the study is triangulation. Two types of triangulation were conducted --- triangulation from different sources and triangulation from different researchers. For triangulation from other sources, various members of the community knowledgeable on the topic, specifically teachers and administrators, were interviewed so that different viewpoints and perspectives on STEM Strand were obtained. For triangulation from other researchers or peer review, a colleague who has expertise in qualitative research was asked to analyze the same data set and determine if the same findings or results will be generated based on the codes, subcategories, categories, and themes. Further, coding sheets, the codebook, a summary of the findings, and the interview transcript were given for scrutiny.

To have a reliable coding scheme, inter-coding processes through inter-coders were done in the study. Two independent persons served as inter-coders. The two inter-coders are qualitative researchers who have publications in international and Scopus-indexed journals. They have training on coding schemes and have already experience the intercoding process. From their rich experience and training, the researcher is assured of valid and reliable results of the intercoding. They were asked to analyze the same set of interview transcripts during the first part of data collection. The inter-coders were asked to code the participants' responses and categorized them as part of the inter-coding procedure by the same coding schemes/techniques as the researcher. The coding of the



Philippine Normal University National Center for Teacher Education

inter-coders was compared with that of the researcher as measures of validity and reliability of the coding strategy of the researcher. The differences in the coding were discussed and the reasons why the differences occurred were figured out. This exchange of ideas helped in the later coding strategy of the researcher so that coded material was produced accurately. However, all data remain anonymous during this inter-coding process.

To ensure the validity and accuracy of the transcribed and translated interview, the transcripts were returned to the participants to check if no other information was added and to check the correctness of each word written in the transcript. The video recordings were also given for their reference. Each participant was asked to sign a form to affirm the correctness of the transcribed interview. Each page of the interview transcript was also asked to be signed by the participants to ensure that no additional information would be added after the form was signed.

Researcher factors such as reactivity and bias that may affect the validity of the study were also taken into consideration. Reactivity as defined by Kolb (2012) refers to “the personal characteristics and the effect the researcher has on the setting or the study” (p. 85). The researcher recognized that the dynamics of the interview is greatly affected by the personal characteristics of both interviewee and interviewer. Differences in background, education, gender, and age may affect the interaction during the interview. Thus, to minimize these, the researcher used probing questions and some fillers to lessen the tension and avoid dead air during the interview. The trust and confidence between the



Philippine Normal University National Center for Teacher Education

researcher and the participants are attributed to the likelihood of sameness and belongingness (being natives of Nueva Ecija and with the same line of work).

To minimize the effect of the researcher bias, utmost reflexivity was done by the researcher through reflections by memoing, examination of all the details, and exploration of the subject matter throughout the stages of the study. Thus, the researcher recorded all his subjective reactions on the participants during the interview. Many of these factors were taken into consideration during the data analysis.

The researcher ensured that future researchers might duplicate the processes done in the study by reporting them in detail. The researcher hopes that the findings can be confirmed so that evidence may support the result. However, it is with high hope that other researchers may understand that replicating qualitative studies may yield or produce different results and findings as an acknowledged limitation of qualitative research.

Phase 2: STEAM Education Framework Development and Validation

Development of STEAM Education Framework

From the analysis of Phase 1, a framework was developed. Based on the analysis phase, the researcher identified the important elements which were inserted in the proposed STEAM Education Framework. The dimensions and aspects of the themes and categories derived from the participants' responses were considered in the framework development. Relevant works of literature were also considered to enrich the data for the framework. The researcher's adviser checked the framework for its accuracy.

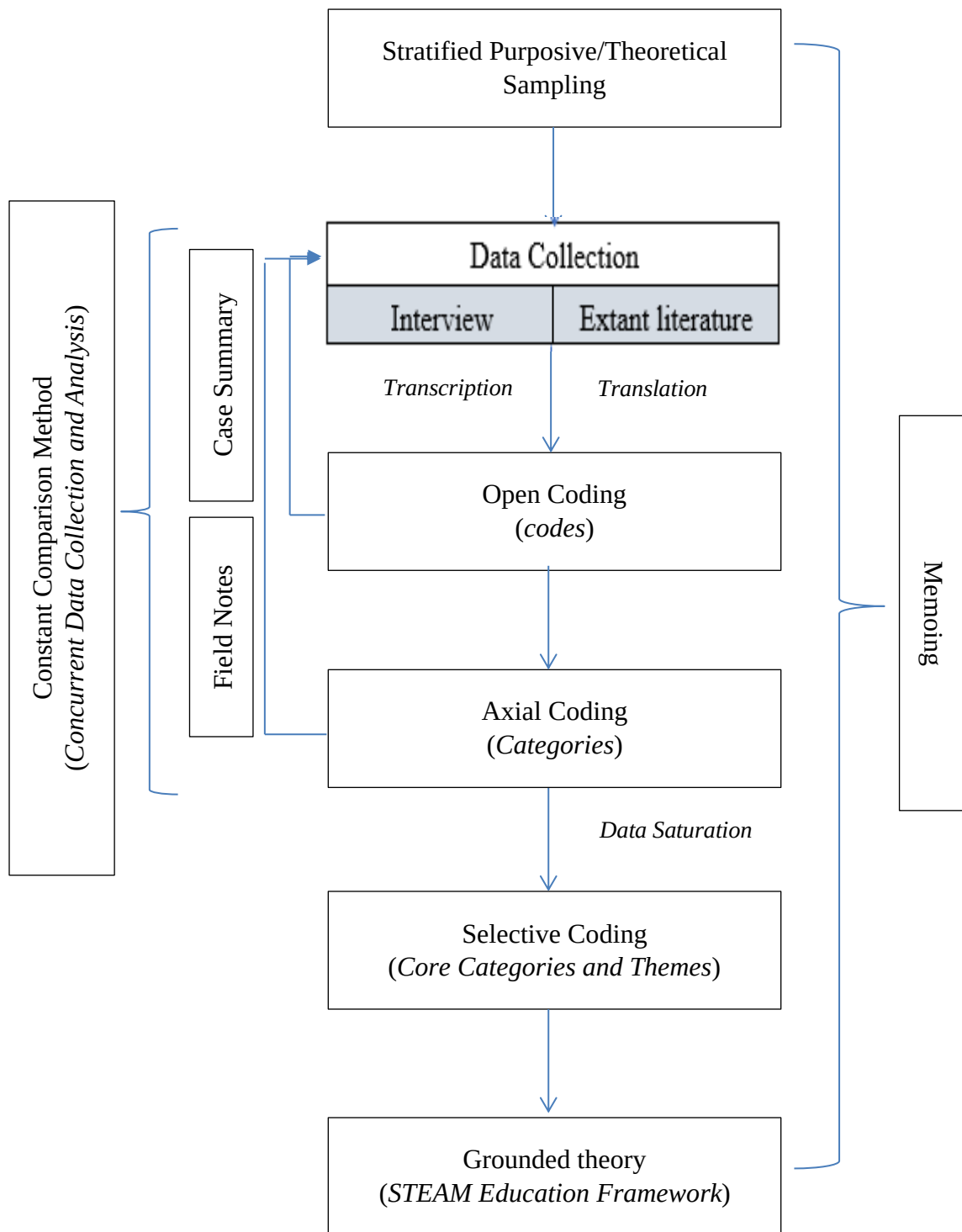


Figure 21. Overall methods conducted in the analysis phase of the study.



Philippine Normal University National Center for Teacher Education

After checking and incorporating the comments and suggestions, a description of the framework was prepared. The framework with its description was sent to the experts for validation. Figure 21 shows the overall process conducted in the first phase of the study up to developing the STEAM Education framework.

Validation of the developed STEAM Education Framework

To validate the developed framework, the Delphi technique was employed. In this method, two or more iterations were needed to improve and validate the developed framework. A panel of five experts in the topic and curriculum and instruction was constituted to validate the framework, training design, and indicators and standards.

As suggested by Skulmolski, Hartman, and Krahn (2007), there are four characteristics that an expert should possess to be part of the Delphi Study, to wit “a) knowledge and experience with the issues under investigation; b) capacity and willingness to participate; c) sufficient time to participate in the Delphi; and d) effective communication skills” (p. 4). These criteria were used by the researcher in selecting the experts. With regard to the number of experts in the panel, Nordin et al. (2012, p. 3) pointed out that “representation is assessed by the qualities of the expert panel rather than its number.” Thus, there are Delphi methods that use three, four, or even eight panelists. In this study, a five-expert panel was utilized. They were experts on STEAM education or in instruction and curriculum. A PhD STEAM Education degree holder who is also a professor in Nepal, a PhD Science Education degree holder who is also an SHS STEM Strand science teacher, two (2) PhD in Curriculum and Instruction degree holders, and a



Philippine Normal University National Center for Teacher Education

PhD Science Education degree holder who is also an Education Program Supervisor (EPS) - Science in Nueva Ecija constituted the panel of expert-validators (see validator's profile in Appendix AD). They were given a letter requesting their expertise and assistance validating the developed STEAM Education Framework (Appendix AE). Attached in the letter are the validation instrument and the proposed framework.



Philippine Normal University
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Validation Instrument for the developed Framework

Name: _____ Date: _____

After reading the description of the framework, kindly answer the following questions.

1. What can you say about the principles, features, and components of the developed framework?

2. Can the framework be applied in a real-world setting? Please elaborate.

3. If you were to design the framework, what other principles, features, or components will you include?

4. What area(s)/component(s) of the framework do you feel that demand or need the most revisions?

5. Do you have any suggestions or comments for the improvement of the framework? Please provide the details. |

Signature of the validator

Figure 22. *The first validation instrument for the developed framework.*



Philippine Normal University National Center for Teacher Education

On the first round of the Delphi technique, the developed framework along with the description of each component (Appendix AF) were given to the experts. Their comments and suggestions were elicited through the open-ended questionnaire (Appendix AG). The questionnaire contains general questions such as “*What can you say about the framework?*,” “*Can the framework be applied in a real-world setting? Please elaborate,*” and “*What are your suggestions and comments for the improvement of the developed framework?*” (Figure 22).

The questionnaire was sent through electronic mail. Many studies and even proponents of the Delphi studies recommend distant communication with the experts rather than face-to-face group meetings since some experts tend to dominate the decision (Green, 2014). Also, having a face-to-face meeting individually with the experts will just rush comments unlike with e-mail communication where they will have more time to think about the developed framework. With this method, the researcher obtained more accurate and richer qualitative data that were used to revise the framework.

The second round of the Delphi technique involves a questionnaire composed of statements answerable in a five-point Likert scale to express their agreement or disagreement (Appendix AH) to validate the revised framework. The comments from the first Delphi round and validation questionnaire of Kissick (2015) were the basis of items in the questionnaire of the second Delphi round. This was provided to the experts for their evaluation along with the resultant framework from the first Delphi round (Appendix AI). Summary of the changes and revisions from round 1 of the Delphi technique was also included (Appendix AJ). On their rating lower than 4, the experts



were asked to state their reason in each item's “remark” box. A consensus of acceptance of the framework was attained when the experts’ rating average on each item was more than 3.75 (Nordin et al., 2012).

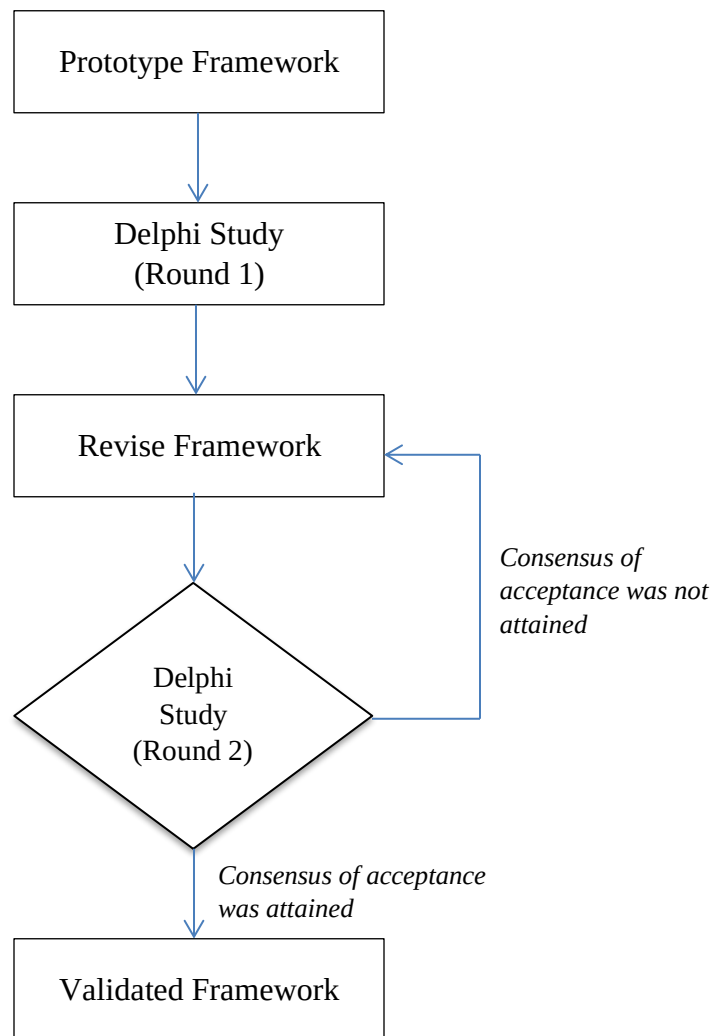


Figure 23. *The schematics of the developed framework validation using the Delphi technique*



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For the item that does not reach the minimum score for the consensus of acceptance, another framework revision was done. The data obtained from the “remark” box of the item where consensus is not attained were used to revise the framework. This was done until all the items in the validation questionnaire met the approval of the experts. Figure 23 shows the schematic diagram of how the Delphi technique was conducted in the study.

Phase 3: Development and Validation of Training Design and Indicators and Standards

After the final approval of experts on the Delphi study for the framework, a training design and a set of indicators and standards were developed anchored on the validated STEAM Education Framework. The produced outputs were validated by the same panel of experts using the Delphi technique. In the questionnaire, experts were asked whether they agree that the developed training design can train STEM teachers for possible implementation of STEAM Education in Senior High School. Also, the experts were asked if they agree that the set of indicators and standards can be used to assess the quality of STEAM education in Senior High School. Further, they were asked to judge whether the outputs are dedicated to the developed STEAM Education Framework. Same with the Delphi method described in the preceding section, training design and sets of indicators and standards were considered valid when at least an average rating of 3.75 in each item is obtained from the experts.



Table 10 shows the stages/phases, instruments, type of instruments, and participants in the study.

Table 10. Overview of the stages/phases, instruments, type of instruments, and participants in the study.

Stage/ Phase	Instruments	Type of instrument	Participants
Analysis	Interview Guide	Interview	11 SHS Science Teachers 11 administrators
Framework development and validation	Expert Validation Questionnaires	Questionnaire	5 experts
	Rating Scale	Survey	5 experts
Development and Validation of Training Design and Indicators and Standard	Expert Validation Questionnaires	Questionnaire	5 experts
	Rating Scale	Survey	5 experts

Ethical Considerations

The researcher sought the approval of the concerned schools before conducting the study to ensure that the study adheres to the ethical standards and guidelines in research of the institutions. The letter request to conduct the study was prepared and submitted to the school division superintendents, principals, and respective HEI presidents. Also, the researcher secured an informed consent letter from the participants to be interviewed. It was explained that participation in the study is voluntary and no incentive in monetary form would be given to the participants in exchange for their



Philippine Normal University National Center for Teacher Education

participation. Their option to withdraw at any time or their refusal to participate was also elaborated. The researcher explained that withdrawal will not affect them in any way and if they do withdraw, they may request that their data be destroyed or deleted unless a de-identifiable state is in place. The researcher also ensured the safety of the participants in the course of the study.

The collected data were treated with confidentiality. Republic Act 10173, also known as the Data Privacy Act of 2012, would be observed in the publication of the study in journals in the interest of participants' anonymity and privacy. Also, the information and related data that were obtained were solely used for the study. To ensure that the participants were given complete information regarding the study, the researcher included a short description of the nature and objectives of the study in the informed consent form. This was repeated during the interview. The storage and handling of data collected from them were also thoroughly explained. Further, it was clarified that neither any identifying information nor their name was used or would be used in research publications, policy briefs, presentations or in any other written outputs resulting from the study. Only a pseudonym of their choice would be in place.

In addition to the informed consent form, consent for video- or audio-recording and transcription was also secured from the participants. In this form, they were assured that the recording would solely be used for the purpose of the study and once checked for accuracy, the transcriptions would be deleted. Transcribing of the interview was done by the researcher as protection to the identity of the participants. Studies mentioned in the study were cited correctly.



CHAPTER 3

RESULTS AND DISCUSSION

This chapter synthesizes and discusses the study's primary outcome in the light of the following: (a) results of the semi-structured interviews through the generated framework of the grounded theory approach; and (b) the products, such as training design, set of indicators and standards sourced out as second-tier validation of the developed framework. Generally, this part offers the findings and the practical implications thereof. Three research questions directed this research: (1) What are the needs and constructs of SHS STEM Strand from different types of high school in Nueva Ecija on the perspective of teachers and administrators in pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, among others for the implementation of STEAM Education? (2) How can these needs and constructs inform the design of a STEAM Education Framework for SHS STEM Strand? (3) What modifications are needed to improve the developed framework based on validation processes: (a) What inputs may be derived from experts? (b) What are the elements and processes of a training design that can be derived from the developed framework? (c) What are the indicators and standards for STEAM Education in SHS that can be derived from the framework? The results are systematically divided into three (3) sections aligned with the study's research questions and general objective, which is to develop a STEAM Education Framework for SHS STEM Strand.



Philippine Normal University National Center for Teacher Education

The first section provides the general profile and other relevant details of the STEM teachers and administrators which are presented in graphic forms, such as by way of a table for participants who are interviewed. The information acquired in this section plays an important element in understanding the context of the results discussed in the next part of this chapter. This section also contains the data on the needs and constructs of the teachers and administrators interviewed from different types of Senior high schools in Nueva Ecija regarding the SHS STEM Strand in terms of the set parameters as mentioned in the research questions. The second section comprises the STEAM Education Framework which is developed and abstracted from the needs and construct of the supported data or documents illustrated in the first section. The final section, the third section, presents the validation result of the panel experts in the developed STEAM Education Framework using the Delphi technique. In this section, the experts' inputs were incorporated to better the developed framework. Further, the third section illustrates the training design, set of indicators, and standards derived from the developed framework and the results of the validation of these products to which the instruments measure what it aims to evaluate. This section will establish content validity through experts' opinions in the area related to inquiry generated using the Delphi technique.

I. Needs and Constructs of SHS STEM Strand in different parameters

This section contains the participant's profile and their perspectives on STEM Education in terms of pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support,



Philippine Normal University National Center for Teacher Education

and others. The results were deduced from the STEM teachers' and administrators' responses to determine the needs and constructs of the SHS STEM Strand of the different types of high school in Nueva Ecija. This section is in accordance with the Research Question 1 of the study.

Profile of Participants and Related Details

To explain the primary themes that emerged from this research, demographic tables (Tables 11 and 12) were created to introduce each participant from the data derived at the early part of each interview. The goal of this arrangement was to establish an easy flow of information for each participant as important outcomes and ideas were discussed in the proceeding sections on the development of the STEAM Education Framework for Senior High School STEM Strand.

Senior High School (SHS) Teachers who specialized in Science and Mathematics and administrators in STEM Strand were chosen as participants. They came from different types of senior high schools in Nueva Ecija to wit: (a) Public Higher Education Institutions (HEIs) with SHS, (b) Private HEIs with SHS, (c) DepEd stand-alone SHS, (d) DepEd integrated SHS, and (e) Private SHS. The participants were chosen using stratified purposive sampling by which initial criteria were set, such as the type of school where the participants are stationed and participants' teaching or administrative experience in STEM Strand which shall be at least three years. Theoretical sampling was then employed to select additional participants, one STEM Teacher and one STEM administrator, to enrich the data and to account for all the variations in adherence to the



grounded theory approach. A total number of 22 participants, 11 STEM teachers and 11 STEM administrators, were engaged in the study using the mentioned sampling techniques. This process is aligned to Creswell's (2007) suggestion that in saturating a model generated through the grounded theory approach, 20 to 30 or 50 to 60 interviews are needed. The summarized profile of the interviewed teachers and administrators are shown in Tables 11 and 12, respectively. Their individual profiles were already shown in Tables 4 and 5 in the previous chapter (see Methodology).

Table 11. The general profile of interviewed STEM teachers

Variable	Category	Frequency (n = 11)
Biological sex	Male	7 (63.64%)
	Female	4 (36.36%)
Age (in years)	24 – 29	4 (36.36%)
	30 – 35	3 (27.27%)
	36 – 41	3 (27.27%)
	42 – 47	0 (0.00%)
	48 – 53	0 (0.00%)
	53 – 58	1 (9.09%)
Highest Educational Attainment	PhD degree holder	1 (9.09%)
	PhD (with units)	1 (9.09%)
	MA/MS degree holder	4 (36.36%)
	MA/MS (with units)	2 (18.18%)
	BS degree holder	3 (27.27%)
Overall length of	3 – 9	5 (45.45%)



Philippine Normal University National Center for Teacher Education

teaching experience (in years)	<i>10 – 16</i>	4 (36.36%)
	<i>17 – 23</i>	1 (9.09%)
	<i>23 – 29</i>	0 (0.00%)
	<i>29 – 35</i>	1 (9.09%)
Length of teaching experience in STEM Strand (in years)	<i>3</i>	4 (36.36%)
	<i>4</i>	7 (63.64%)
Specialization	<i>Biology</i>	3 (27.27%)
	<i>Chemistry</i>	2 (18.18%)
	<i>Physics</i>	2 (18.18%)
	<i>General Science</i>	1 (9.09%)
	<i>Mathematics</i>	2 (18.18%)
	<i>Information Technology</i>	1 (9.09%)

Table 11 illustrates the general profile of teacher participants with comparison in number in terms of sex, age, highest educational attainment, overall length of teaching experience, length of teaching experience in STEM Strand, and specialization or expertise. For STEM teachers, seven males and four females participated in the study. They are Teacher Flor, Teacher X, Teacher Michael, Teacher Jordz, Teacher DeoGirl, Teacher Pooh, Teacher Cza, Teacher Maestro, Teacher Alfred, Teacher Joe, and Teacher Bart. All STEM teachers' pseudonyms were tagged with "Teacher" for easy recall and better distinction with STEM administrators in the proceeding section.

On the average, the age of the teacher-participants is 34.82 years old with the highest frequency in the age bracket of 24 to 29 years old. Most of them were MA/MS



Philippine Normal University National Center for Teacher Education

degree holders, but three participants were BS degree holders. It is important to note that some interviewed participants were non-education degree holders.

Overall, the participants' length of teaching experience is from at least 3 to 35 years with an average of 11.64 years. With regard to the length of their experience at STEM Strand, seven participants have already taught for four years since the start of senior high school in 2016, while the remaining participants have three years of teaching experience in the STEM Strand, which is in line with the initial qualification as teacher-participant of the study. In terms of specialization, the greatest number of teacher-participants has expertise in biology followed by chemistry, physics, and mathematics. There were two lone participants; each has a different field of specialization, one is general science and the other is information technology.

Table 12. The general profile of interviewed STEM administrators

Variable	Category	Frequency (n = 11)
Biological Sex	<i>Male</i>	5 (45.45%)
	<i>Female</i>	6 (54.55%)
Age (in years)	<i>25 – 30</i>	3 (27.27%)
	<i>31 – 36</i>	3 (27.27%)
	<i>37 – 42</i>	4 (36.36%)
	<i>43 – 48</i>	0 (0.00%)
	<i>49 – 54</i>	1 (9.09%)
Highest Educational Attainment	<i>PhD degree holder</i>	3 (27.27%)
	<i>PhD (with units)</i>	2 (18.18%)
	<i>MA/MS degree holder</i>	2 (18.18%)



Philippine Normal University
National Center for Teacher Education

	<i>MA/MS (with units)</i>	3 (27.27%)
	<i>BS degree holder</i>	1 (9.09%)
Overall length of teaching experience (in years)	<i>5 – 10</i>	4 (36.36%)
	<i>11 – 16</i>	3 (18.18%)
	<i>17 – 22</i>	4 (36.36%)
	<i>23 – 28</i>	0 (0.00%)
	<i>29 – 34</i>	1 (9.09%)
Overall length of administrative or supervisory experience (in years)	<i>3 – 4</i>	3 (27.27%)
	<i>5 – 6</i>	4 (36.36%)
	<i>7 – 8</i>	2 (18.18%)
	<i>9 – 10</i>	2 (18.18%)
Length of administrative or supervisory experience in STEM Strand (in years)	<i>3</i>	8 (73.73%)
	<i>4</i>	3 (27.27%)
Position	<i>Principal</i>	2 (18.18%)
	<i>Assistant Principal</i>	1 (9.09%)
	<i>Focal Person</i>	2 (18.18%)
	<i>SHS Coordinator</i>	2 (18.18%)
	<i>STEM Coordinator</i>	2 (18.18%)
	<i>STEM Subject Group Head</i>	2 (18.18%)

Meanwhile, Table 12 shows the general profile of the STEM Administrators interviewed in terms of sex, age, highest educational attainment, overall length of teaching experience, overall length of administrative or supervisory experience, length of administrative or supervisory experience in STEM Strand, and position. There were five males and six females who were interviewed as STEM Administrators. They are Admin



Philippine Normal University National Center for Teacher Education

Rina, Admin Armier, Admin Jam, Admin Airam Berns, Admin Lars, Admin Will, Admin Chard, Admin Shalom, Admin Sensei, Admin Jed, and Admin Spiderwoman. The word "Admin" was added in their pseudonym to entail an easy comparison with the STEM teachers interviewed.

In terms of age, the youngest interviewee is 25 years old and the oldest is 54 years old with an average age of 36.10 years old. Most of the interviewees are PhD degree holders and with earned academic units in their MA/MS degrees. In one case, there is a BS degree holder who is also a STEM administrator. Different expertise and specialization were noted for the administrators, such as English and Literature, but the majority of them are in the field of science education.

With regard to their overall length of teaching experience, the majority has 5 – 10 years and 17 – 22 years. Meanwhile, ten years is the highest while three years is the lowest in terms of the overall length of administrative or supervisory experience. In observance with the qualification set in this study in selecting the participants with a minimum of three-year experience in STEM administration, eight participants have three years while three participants have four years of engagement in such a function.

As defined in the study, administrators are the immediate supervisors of teachers and the direct overseer of the STEM Strand in the school. However, due to the different organizational structures of HEIs, private, and DepEd schools, different names were called for this position, such as principal, assistant principal, SHS focal person, SHS Coordinator, STEM Strand Coordinator, and STEM Subject Group Head. Two



Philippine Normal University National Center for Teacher Education

participants for each position were interviewed except for the position of Assistant Principal in which only one participated.

Overall, 12 males and 10 females were interviewed in the study. The diverse range of variability and characteristics of interviewed teachers and administrators using stratified purposive and theoretical sampling ensure the productivity of the data obtained and analyzed in the study. This variability on the attributes of participants made certain that various perspectives and viewpoints on STEM Strand for the development of the framework were obtained by looking into different factors such as differentiated expertise and teaching of subjects like Mathematics, Chemistry, Physics, Biology, and inclusion of highly specialized subject such as Robotics, length of teaching experiences (3 – 35 years), highest educational attainment for the interviewed teachers (BS, MA/MS, PhD), difference in the length of administrative experience (3 – 10 years), length of teaching experience before being promoted as an administrator (5 – 34 years), among others for the administrators. The information obtained guaranteed the satiety of the development of codes and categories that are beneficial in the grounding of data towards the development of the framework.

Different Constructs and Needs on STEM Strand of Teachers and Administrators

Table 13 shows the needs and constructs on the STEM strand derived from the participants' responses regarding pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, and others. According to Patton (2002), qualitative data interpretation entails



elucidating the results by answering why questions, highlighting the significance of specific findings, and putting patterns into an analysis. The analysis grew from examining and evaluating the participant's responses to each STEM Education issue from their point of view. The data paved the way to understand the needs and constructs of participants in STEM education which used interpretative findings from the interviews.

Table 13. Needs and Constructs emanated from the interview responses

Categories/ Elements	Sample Verbatim Responses	Needs	Constructs
<u>Pedagogical character and traits of teachers</u>	<i>For me, there are two main characteristics needed to be qualified in teaching STEM Strand. First, professional which means that a STEM teacher need to be updated in the different trends and issues in Science Education by attending seminars, workshops and continuing education (MS and PhD). Second is they could teach any areas in science and as well in research</i>		Qualifications of STEM Teachers
	<i>The teacher must be a skilled leader and have passion that can be observed through the lessons. Also, the teacher must have managerial talent in the classroom and have satisfactory results based on the student's performance.</i>		Qualities of STEM Teachers
	<i>STEM teachers must have skills especially in research. It is an awkward fact that the learners are doing their research but the teachers are doing nothing about it. It is important to engage the teachers therein, to have the knowledge to be ready in a very feasible case that the learners will</i>		Must-have skills of STEM Teachers



Philippine Normal University
National Center for Teacher Education

	<i>question or ask help in the STEM research project.</i>		
<u>Curriculum</u>	<i>Bio, calculus. pre-cal and basic cal, they have. Also chemistry has a learning guide, it seems there is also teacher's Guide. Physics, none. So everyone is really diligent in finding learning resources really.</i>	Lack of teaching and learning resources	
	<i>That's why the curriculum is also really different because now it's congested. Based on my experience you are always repeating law of motions from Junior High to Senior High. Grade 7, 8, 9, 10 as well as Senior high?</i>		Congested
	<i>The Division Office gave us five graphing calculators that could be used to interpret data and for data visualization. But I did not demonstrate or show it in the class even once since I do not know how to use it. There are so many buttons and functions that I am unfamiliar with. I hope there is training for the teachers on how to use it."</i>	Lack of training in using lab equipment	
	<i>I think the curriculum and design is comprehensive enough for the students since all the necessary subjects needed are there which can able to develop their skill especially in doing research. They are being exposed to social and experimental research since they have that Practical Research 1 and 2. Likewise, they also have the subject Inquiries, investigations, and immersions in which their scientific skills are also enhanced and a capstone research that showcases their talent and skills in doing scientific research.</i>		Comprehensive



Philippine Normal University
National Center for Teacher Education

	<i>Students would have learned better if the experiment was done in groups. Acquisition of competencies and practical skills inherent in the laboratory experiments will be ensured if the materials are enough.</i>	Limited learning materials	
	<i>The STEM strand is very ideal and recommendable to any students who wish to take STEM related courses in the future.</i>		Ideal
	<i>One thing that concerns me is that not every school can afford to provide a laboratory that is needed for each curriculum especially in Science subjects.</i>	Lack of laboratory rooms	
	<i>The STEM curriculum is well-designed for any students that aims to pursue STEM related courses in college. The specialized subjects will really prepare them for the future.</i>		Well-designed
	<i>It is great but it needs to be more strict when it comes to admission of the STEM students.</i>	Provision of entrance exam	
	<i>STEM sounds interesting and challenging to learners. That is why academically, inclined students choose this strand yet, they understand that they should also keep pace with pressure. Why not include in STEM the subject of Arts so that STEM students can also express creativity in their research work and experimentations.</i>	Addition of other subjects to the curriculum	
	<i>There are students who would talk to you that at the middle of the semester that they don't want to pursue their SHS anymore in STEM Strand. When I</i>		Students transferring to other strands



Philippine Normal University
National Center for Teacher Education

<i>asked them why they just reason out that they realized that STEM strand is no longer fit for the course they want in college.</i>		
<i>Hopefully, STEM course offerings will be consistent for both public and private every semester because we have so many problems. We have transferees from other provinces or from private schools who come to us. We have no right to reject transferees. Our problem is that they did not get the same subjects. There are schools that offer Physics first, while some already get their General Biology in Grade 11 while it is supposed to be in Grade 12.</i>	Need of one schedule of subject offerings	

Table 13 (see Appendix AN for the whole table) summarizes the needs and constructs emanated from the responses of participants regarding their viewpoints with STEM curriculum in terms of different parameters. The interview questions on pedagogical character and traits of teachers revealed the participants' construct on the qualifications, qualities, and must-have skills of a teacher teaching in STEM Strand. In terms of curriculum, the participants shared their concepts of the curriculum as well-designed, congested, comprehensive, and ideal. The participants also mentioned their needs as they noted the lack of teaching and learning resources, availability of laboratory rooms, and limited learning materials such as equipment and chemical reagents. Furthermore, the interviewed participants observed the limited training provided when there is new science equipment in the school. The researcher also noted their issues such



Philippine Normal University National Center for Teacher Education

as on having entrance exams on STEM strand, students who transfer to other strands, the inclusion of other subjects, and the various schedule offerings of subjects in different schools. On the other hand, interview questions on instruction and delivery resulted in the need to enhance STEM teachers' content and pedagogical knowledge and the understanding of the pedagogical strategies employed by STEM teachers. The participants also explained in this part the importance of licensed teachers and their predicaments on having heavy workload and misalignment of the subjects they handled with their specialization.

Fundamentally, the interview questions on the feedback system expounded the STEM teachers' innovative assessment strategies and effective assessment tools. The administrators were able to impart their constructs on their leadership, management, support, and partnership with the stakeholders. In terms of the learning environment, the participants shared the need for students' safety and security. They emphasized the need for an environment free from discrimination and one that acknowledges diversity and inclusivity. Lastly, interview questions on institutional support established the needs for training, seminars, workshops, linkages with the community, parent collaboration, and support from Local Government Units (LGUs) and Non-governmental Organizations (NGOs).

The aforementioned needs and constructs of the participants will be tackled comprehensively in the next section.



II. Themes from the grounded theory and the emergent STEAM Education Framework

This section presents the findings anchored on the second research question of the study, "How can these needs and constructs inform the design of STEAM Education Framework for SHS STEM Strand?" The section, divided into three areas, explains the gathered information vital to the development of the framework. The first area explains comprehensively the categories and themes generated from the grounded theory. This area establishes the needs and constructs of the STEM Strand from the perspective and viewpoints of the teachers and administrators. The second area gives an overview of the emergent themes from the interview in relation to STEAM Education. The third area provides descriptions of the obtained emergent theory and the visual illustration. The operational definitions of the developed framework's different themes and core categories in this area were provided.

Different Codes, Categories, and Themes generated from the Grounded Theory

This section summarizes the extensive data uncovered during the investigation and the findings of various levels of data coding. The interview transcripts underwent a coding procedure from the needs and constructs obtained from the first research question. The coding process moves from open coding through axial coding to selective coding, where the theory arises from the key themes following the Strauss-Corbin method to grounded theory. Table 14 depicts the researcher's interpretation of the transition from open and axial coding to selective coding. The table outlines the process of generating



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axial codes (categories and subcategories) from the open codes and forming selective codes (themes) from the axial codes. The open codes listed in the table came from the analysis of the participant interview transcripts using the coding techniques such as descriptive coding, process coding, in vivo coding, and simultaneous coding employed by the researcher. An illustrative representation of axial codes (categories) derived from participant interviews and pertinent final coding terms and topics on STEM Education is presented to aid in the development of the STEAM Education framework.

Table 14. Sample Open, Axial, and Selective codes derived from the responses of the participants

Sample Open Codes	Axial Codes (Categories and Subcategories)	Selective Codes (Themes)
Expertise in subject matter Background in STEM fields Education graduate with major in science and math	<i>Aligned specialization</i>	Teachers' Qualifications
Graduate of a master's degree PhD holder	<i>Advanced degrees</i>	
Licensed teacher Board examination passer	<i>BLEPT passers</i>	
Enough experience in the profession Long years in teaching	<i>Sufficient teaching experience</i>	
Specialized skills Laboratory trainings Advanced skills in the subject	<i>Specialization training</i>	



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Knowledgeable		
Mastery of the subject matter	<i>Subject Matter</i>	
Have good content knowledge	<i>Competency</i>	
Updated to different trends		
Attends training and seminars	<i>Lifelong Learning</i>	
Continuous learner	<i>Competency</i>	
ICT literate		
Technology integration	<i>Technological</i>	
	<i>Competency</i>	
Being a researcher		Teachers' Competencies
Research skills		
Knowledge in research techniques	<i>Research Competency</i>	
Verbal and non-verbal skills		
Good communicator	<i>Communication</i>	
Listening skills	<i>Competency</i>	
Being a model and mentor		
Character flexibility	<i>Social-Emotional</i>	
Motivator and molder	<i>Competency</i>	
Communication approaches		
Transmitting/communicating information	<i>Communicating Teachers</i>	
Promoting student response		
Active learning/participation		
Collaborative approach	<i>Engaging Teachers</i>	Teacher Pedagogical Characters
Social interaction		
Experiential-based learning		
Critical pedagogy	<i>Transforming Teachers</i>	
Discussion of community issues		
Complete learning standards		
Broad scope of the lessons	<i>Comprehensive yet</i>	STEM Curriculum refinement
Too much content	<i>congested</i>	



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Work immersion Preparation for work environment Ambitious	<i>Work oriented yet very idealistic</i>	
Planned curriculum Lack of learning and teaching resources Limited materials	<i>Well-designed yet problematic</i>	
Values formation Character development Building positive behaviors	<i>Character Education Subjects</i>	
Medicine-related subjects Environmental concerns Absence of microbiology	<i>Other science-related courses</i>	Discipline-integration
Incorporation of aesthetics Humanizing the curriculum Expressing creativity	<i>Arts integration</i>	
Constant space for reflection Feedback mechanism Excellent work	<i>Sound Administration</i>	
Managing school resources and system Professional openness and honesty Recognizing teachers' diversity	<i>Effective Management</i>	
Strengthening educational connections Establishing educational networks Building partnership with stakeholders	<u>Stakeholder Engagement</u>	Administrator's leadership and management
Acting on challenges and possibilities Observing integrity at work Managing personal	<u>Personal Excellence</u>	

Transformative Leadership



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effectiveness

Achieving the desired learning objectives

Leading curriculum and development implementation
Monitoring and assessing teachers undertaking

Instructional Leadership

Providing well-defined decisions

Creating learning innovations
Strategizing school's goal direction

Innovative Strategic Thinking

Smart decisions

Analytical thinking

Practice cognition of thinking

Critical Thinker

Thinking outside of the box

Intrinsically motivated

Independent

Creative

Real and practical intelligence

Making connections

Active learner

Reflective

Radical ideas

Naturally curious

Examining learning

Innovative

Student's skills

Collaborative approach

Reflective questions

Division wide-exam

Innovative assessment strategies

Role-playing

Simulations

Authentic assessment

Traditional assessment

Assessment tools

Assessment practices



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Human factors		
Non-human factors	<i>Environmental factors</i>	
Genuine respect		
Professionalism		
Sense of belongingness	<i>Teachers Affective Traits</i>	
Diversity and inclusivity		
Protection from violence	<u>Classroom</u>	
No sensitive issues	<u>concerns</u>	
		Safe Learning Space
Constructive feedback		<i>Classroom</i>
Classroom rules and		<i>Climate</i>
procedures	<u>Classroom</u>	
Monitoring of students	<u>Management</u>	
Presence of safety equipment		
Safety of building	<i>Physical Environment</i>	
Security		

Provision of admission exam		
Readiness in STEM strand		
Additional requirement for admission	<i>STEM Entrance Examination</i>	
Changing of strands		
Transferring to another track	<i>STEM students switching</i>	
Taking up non-STEM field	<i>strands</i>	
Subject offerings of school		
Various schedule of subjects	<i>Harmonization of</i>	
Transfer of students	<i>subjects</i>	Policy Orientation and harmonization
Misalignment of subjects with specialization		
Too many subjects	<i>STEM Teachers with</i>	
Full workload	<i>many and mismatched</i>	
	<i>subjects</i>	
Capable and competent teachers		
Teachers with license	<i>Non-board passer</i>	
Qualified teachers	<i>teachers</i>	



Philippine Normal University National Center for Teacher Education

Capacity-building Enrichment programs Team-building activities	<i>Institutional support</i>	
Collaboration with parents Parent-teacher association Donation of classroom facilities	<i>Parent Involvement</i>	Partnership and Support
Establishing linkages Support from Local Government Units (LGUs) Partnership in work immersion	<i>Community Partnership</i>	

The information presented in Table 14 such as sample open codes and axial codes were used to generate the eleven themes presented in the study. For example, the last theme, *Partnership and Support*, was deduced from the axial codes, *Institutional Support*, *Parent Involvement*, and *Community Partnership*. The axial code, *Community Partnership*, was derived from the sample open codes: *establishing linkages*, *support from Local Government Units (LGUs)*, and *partnership in work immersion*. The complete list of open codes is presented in Appendix AC. Table 15 shows the number of open and axial codes produced and used to develop the themes. From the analysis of the interview responses, a total of 286 open codes, 41 axial codes (categories), and 11 selective codes (themes) were generated (see Appendix AC). The axial codes from each theme provide its findings including subcategories and categories that aided in the discovery of the theme's dimensions and properties.



Table 15. The number of open and axial codes used to produce each theme

Selective codes (Themes)	Number of axial codes (category)	Number of open codes
Teacher's qualifications	5	13
Teacher competencies	6	45
Teacher pedagogical characters	3	31
STEM curriculum refinement	3	39
Discipline integration	3	16
Administrator's leadership and management	3	32
Student' skills	4	20
Assessment practices	2	19
Safe learning space	4	24
Policy reorientation and harmonization	5	21
Partnership and support	3	26
TOTAL	41	286

The open coding stage entailed scanning all 22 interview documents for instances of the almost 350 codes that were first chosen. Coding and memos were done manually as well as using a word processing system. Following multiple readings of the transcripts, open coding begins by detecting concepts and patterns across the text. The primary step for the researcher was conceptualization, which was followed by checking of the memos, field notes, and labeling the phenomena. The codes were recorded to remove any



Philippine Normal University National Center for Teacher Education

potential duplication and merge some of the codes into a stem code. The refinement process resulted in 286 open codes. In order to move the data onto the axial coding phase, the open codes were examined and categories were allocated. The open codes were double-checked and triple-checked to make sure they were in the correct category. The transcripts were re-read before completing the categories to ensure that no code is missed. The researcher avoided naming categories from the precise open codes when establishing the axial codes. For example, open codes such as *inclusion of arts*, *humanizing the curriculum*, and *incorporation of aesthetics* produced the category, *Arts integration* (Table 14). With the detailed classification of the open codes, 41 axial codes or categories were made. Of the 41 categories, two categories, transformative leadership and classroom climate, have four and two subcategories, respectively.

In addition, the axial codes were derived from determining the dimension and aspect established from the open codes. From these properties and categories, selective codes were created. Figure 24 presents a sample of how the interview questions resulted in the open or emergent codes to the theme and its axial codes. From the two interview questions, 45 open codes were produced and distributed into six categories providing the different dimensions and aspects for the theme, *Teachers Competencies*. Sub-categorical and thematic variations exhibit dimensional characteristics of each subject (Saldana, 2009), demonstrating participants' knowledge level along a spectrum toward the essential knowledge base and occasionally illustrating positive and negative connotations and notions related to STEM Education.

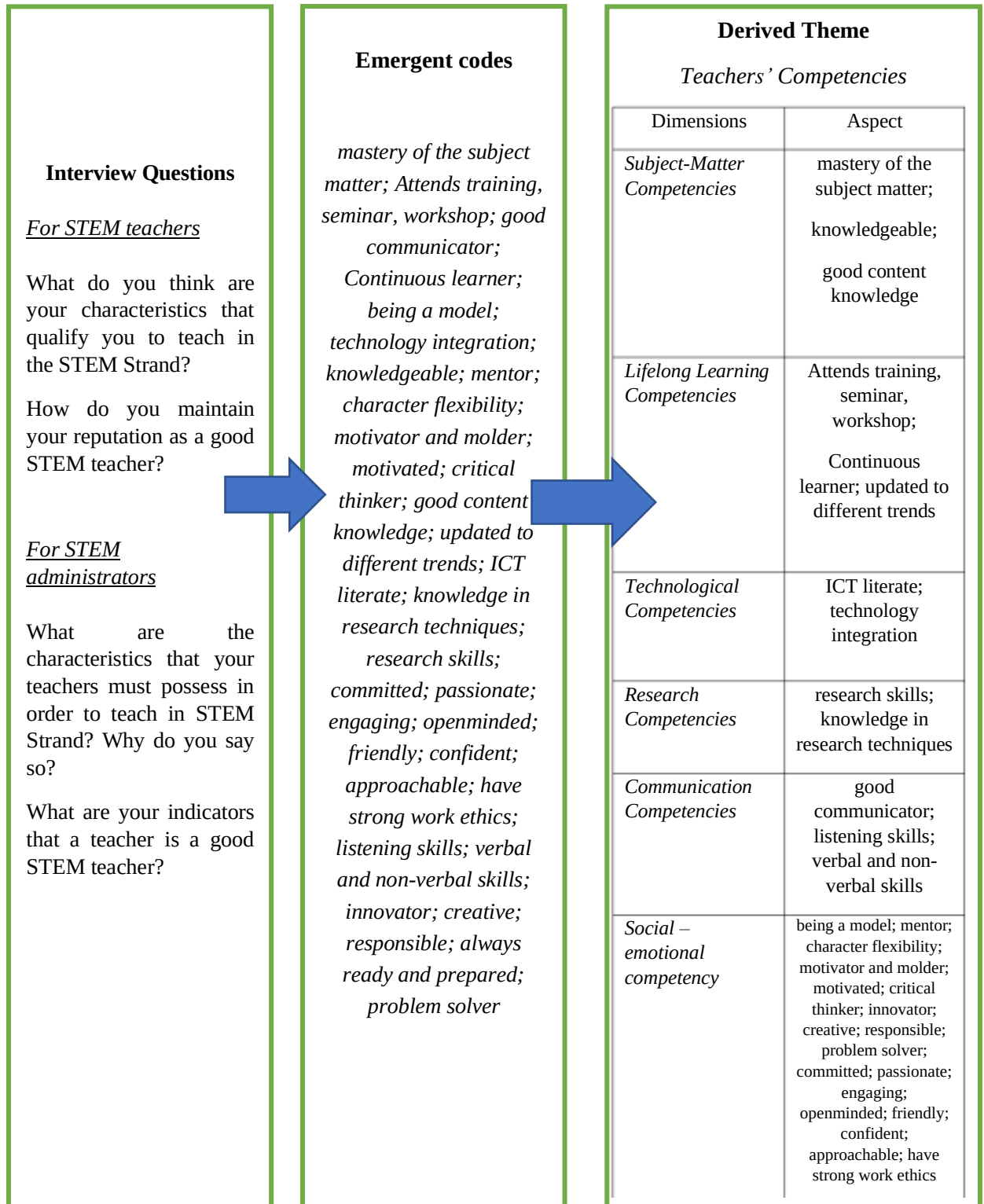


Figure 24. Process of deriving themes with its aspect and dimensions



Philippine Normal University National Center for Teacher Education

Using the coding process and constant comparative method analysis, 11 core categories or themes emerged and were identified to wit: *teacher's qualifications, teacher competencies, teacher pedagogical characters, STEM curriculum refinement, discipline integration, administrator' leadership and management, student' skills, assessment practices, safe learning space, policy reorientation and harmonization, and partnership and support*. Each theme with its categories and properties is explored and explained in detail in the next part. Exemplars are offered to supplement researcher interpretations by employing participants' words to exemplify theoretical concepts revealed by examining participants' tacit knowledge at the sub-categorical, categorical, and thematic levels.

1. Teachers' Qualifications

One of the constructs given by the interviewees is the qualification of the teachers teaching in the STEM Strand. Most of the interviewees recognized that these qualifications play a significant role in the successful teaching-learning process in the SHS STEM Strand. They believe that a teacher must be qualified in the field since they shape and mold the minds of the future generation of professionals; hence, they should fit the role. Unqualified teachers can create problems that may have negative effects on the educational system.

Figure 25 exemplifies the perspectives on different qualifications of teachers teaching in the STEM Strand. Administrators, as well as teachers, believe that the qualification of teachers on the STEM Strand is an important aspect or dimension in the STEM curriculum.

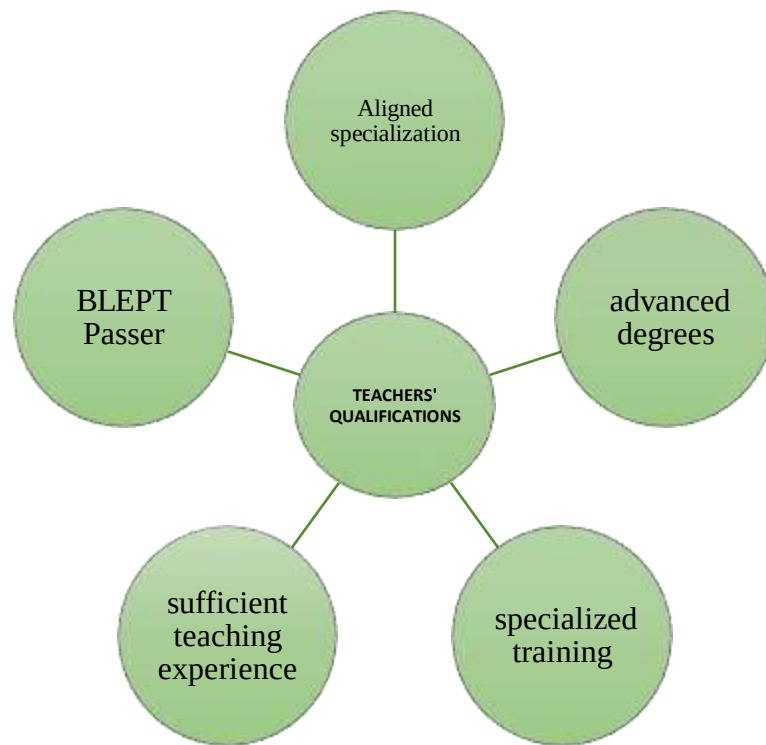


Figure 25. *Qualification of the teachers in STEM Strand sourced from the participants*

Teachers should have specialization aligned with the subjects in the STEM Strand, that is, they should have a background or expertise in science or math. The participants emphasized that teachers should be graduates of any course in the field of science or mathematics or Education degree with a specialization in science or mathematics. Although this is a basic requirement, this is very important because a teacher should have a full understanding of the subject matter he or she is teaching (Ababio, 2013). This was pointed out by Admin Armier, a principal in a public HEI STEM Strand school, in the interview



Philippine Normal University National Center for Teacher Education

"They must be graduates of science courses so that they can deliver the content. That should be the basic requirement. And if a teacher is a graduate of science course, we can expect him or her to be inclined with science teaching, so everything follows."

Admin Airam Berns, an SHS Coordinator in a Private school, likewise added that

"Teachers in the STEM Strand should have their specialization aligned with the aforementioned strand; meaning, they should have the right set of skills to deepen the learner's potential and abilities."

However, for the participants, it is not enough that one has a degree related to the STEM field, but one should also have advanced degrees such as master's (MS/MA) and doctor's degree (PhD) to impart more knowledge on STEM subjects. This is the concern of Admin Lars as he asserted, *"It would be better if the teacher is a graduate of master's degree because the learners in STEM strand have beyond par of academic profile."* Miller and Roza (2012) posited that advanced degrees such as MA and PhD play a role in improving practice and performance of teachers. These degrees gave teachers an additional preparation that could enhance their skills and knowledge, which will help them solve instructional challenges and cater to their student's learning needs. In the same study, Miller and Roza (2012) proved that teachers with master's degrees in science or math positively affected the students' performance in STEM disciplines. Hence, MA and PhD degrees equip the STEM Teachers with specialized skills and knowledge in such a way that it could be transmitted to the students.



Philippine Normal University National Center for Teacher Education

The participants also see specialized training on the subject that one teaches as an additional qualification since they believe that the laboratory skills one gained from the training could be permeated to the students. Further, the participants thought that a teacher should be a Board of Licensure Examination for Professional Teachers (BLEPT) passer before teaching in the STEM Strand. Generally, this is an indispensable requirement, yet DepEd accepted teachers without the necessary licensure examination in 2016 since mass hiring of teachers was necessitated at that time to fill the vacancy of teaching positions for the creation of SHS. This information is provided in DepEd Order No. 3 s. 2016 titled *"Hiring Guidelines for Senior High School (SHS) Teaching Positions Effective School Year (SY) 2016 -2017,"* wherein the minimum educational attainment to be hired for permanency is bachelor's degree major in the relevant strand and if not BLEPT Passer, they must pass the said licensure examination within five years of employment. On the one hand, Public and Private HEIs set higher qualification standards for the permanent status of their teachers, in which case an applicant shall possess at least a Master's degree relevant in the academic area to be taught as stipulated in the Civil Service Commission (CSC) Memorandum Circular No. 17 s. 2013 [*"Qualification Standards for Faculty Positions/Ranks in State Universities and Colleges (SUCs) and Local Colleges and Universities (LCUs)"*].

Moreover, sufficient teaching experience is also a key criterion for them as Teacher Jordz, a Mathematics Teacher, commented,

"...this is my 19 years of teaching junior high school mathematics and 4 years of teaching Mathematics for senior high school. I believe with that; I am fit to teach in STEM Strand."



Philippine Normal University National Center for Teacher Education

This is also true with Admin Airam Berns as she remarked,

"The teaching experience should also be enough to ensure that he or she has the skills and understanding of the profession."

These statements from participants only show that since teaching is an essential profession, qualification is considered to be a big factor for the STEM Strand. Good teacher qualifications are seen to be more critical than ever as teachers are put into the spotlight since the dismal student's performance on math and science in international assessment scales such as Trends in International Mathematics and Science Study (TIMSS) 2019 and Programme for International Student Assessment (PISA) 2018. The result is attributed to many unqualified teachers. In fact, the Department of Education (DepEd) recognizes the TIMMS and PISA results as a reflection of the gaps and issues in basic education, particularly in students' performance and teacher quality (Dela Cruz, 2019). In response, DepEd's primary solution in addressing these issues is to upskill and reskill the teachers and administrators through a comprehensive and dedicated professional development program (San Juan, 2019).

Qualified teachers produce high-quality teaching which is essential to the effectiveness of the teaching-learning process (Guerriero, 2014). This is tantamount to comparing qualified teachers to the most effective teachers. Several studies (Eckert, 2013; National Science Board, 2016; Olagbaju, 2020; Shober, 2012; Wedel, 2021) have shown significant positive effects of teacher qualifications such as years of teaching experience, licensure examinations, and having advanced degrees on the student's



Philippine Normal University National Center for Teacher Education

achievement. This direct correlation emphasized the needs of a qualified teacher as the public also believe, based on a survey, that the "high-quality teaching from qualified teachers is indispensable to success in student learning" (Johnson, 2021, p. 1571).

2. Teachers' Competencies

Aside from teacher qualification, another construct given by the participants is the teacher's competencies. Katane, Aizsila, and Beitera (2006) defined competencies as "the set of knowledge, skills, and experience necessary for the future, which manifests in activities" (p. 44). Knowledge alone will unlikely develop the competencies of teachers. Teachers' knowledge and skills development and their teaching practices improve as they gain experiences in their profession (Podolsky, Kini, & Darling-Hammond, 2019). These competencies are needed as the teachers are one of the driving mechanisms of a sustainable educational system. Thus, the quality of education could be related to the competence of the teachers as competent teachers provide quality education and quality science education as well (Phin, 2014).

From the response of interviewees, teacher competencies can be divided into six subcategories: subject-matter competency, lifelong learning competency, technological competency, research competency, communication competency, and emotional and self-attributed competencies (Figure 26).

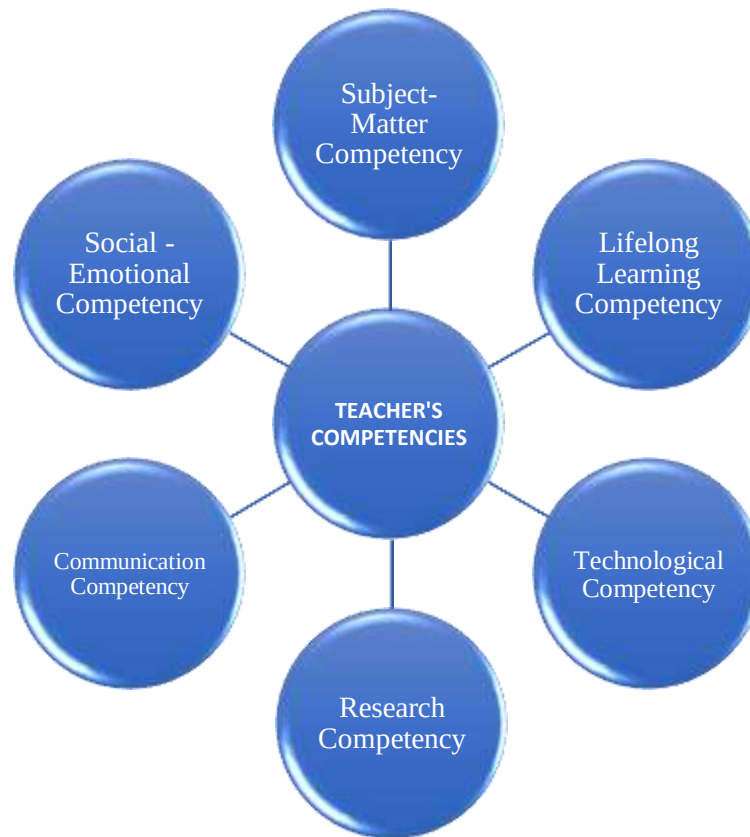


Figure 26. *The six teacher's competencies as perceived by the participants.*

Subject-Matter Competency

Subject-matter competency deals with the mastery and overall knowledge of the teachers on the subject they teach. This construct is considered to be the most important competency of many participants as this competency is highly needed to transfer knowledge to students. Even the STEM Administrators set the subject mastery and its alignment as essential factors in hiring teachers. As Admin Rina shared,

"So, in terms of content, the teachers should have a good mastery especially in Physics, Chemistry, and those difficult subjects that need



Philippine Normal University National Center for Teacher Education

specialized teachers. So, I cannot, we cannot hire teachers to teach chemistry who are non-chemistry majors."

Interviewed teachers share the same sentiments. They think that their knowledge and mastery of the subject matter also influence students' interest on the topic and in the subject as a whole. As Teacher Pooh claimed,

"....you must be knowledgeable in the subject. It's difficult when you just pretend in front of the students. If you want to teach it, but you cannot explain it well, it is just a waste. So, the children also seem to lose their interest, and they say, "What is that teacher saying?"

However, the confidence of teachers on the subject matter was influenced mainly by their undergraduate courses, as revealed in the study. Non-education graduates (BS ECE, BS Nursing, BS Chemistry, BS Biology) are more confident to teach in terms of content than Education graduates, as reflected by their answer to the question, "On a scale of 1 to 10, how do you rate your overall knowledge in your subject?" Teachers DeoGirl (BSBiology graduate), Alfred (BSNursing Graduate), X (BSECE graduate), and Pooh (BSIT graduate) answered ranging from 9 to perfect 10, while Teachers Cza (Math major), Flor (Biology major), Bart (Physics major), Maestro (General Science major), Joe (Chemistry major), Jordz (Math major) and Michael (Physical Sciences major) answered 6 to 7. Data analysis confirms that this difference in their rating is due to their undergraduate courses, as reflected in some answers of the interviewed teachers.

"10, since I am graduate of Bachelor of Science in Electronics and Communication Engineering." (Teacher X, Physics Teacher)



Philippine Normal University National Center for Teacher Education

"9, because I took advance topics on the subjects I am teaching right now during my undergraduate courses." (Teacher Pooh, Robotics Teacher)

"10. Topics that are in the STEM Strand Biology is very basic for us because we are purist in the field." (Teacher DeoGirl, Biology Teacher)

"6. There are some lessons which I am not confident to teach because I have no prior experience and detailed training on it." (Teacher Flor, Biology Teacher)

This difference in rating seems obvious since non-education graduates have more content subjects on the field, but the disparity in the level of content knowledge and confidence to teach the subject is surprising. This result put a clear indicative line on the content knowledge as well with the subject-matter competence of education- and non-education graduate teachers in the STEM Strand. However, teachers' content knowledge is vital since the content of the subjects in Senior High School is more advanced than that of Junior High School. This advancement is to augment learners' knowledge in their respective fields since the general subjects in college courses were not offered anymore; thus, STEM students are expected to learn the rudiments, particularly in science and mathematics subjects during their SHS. In this regard, students were enrolled in more advanced subjects without the basic prerequisites during their freshman year in college towards their specialization in the courses. This situation exemplifies the need for greater content knowledge from SHS teachers to ensure the smooth flow of the students' transition from senior high school to college.

Content knowledge, an important component of subject-matter competency, has been defined as the understanding of key information, ideas, theories, notions, principles,



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and the totality of a discipline that was obtained through learning or teaching (Ball, Thames, & Phelps, 2008; Kleicmann et al., 2012; Phelps et al., 2014). Without such, it is expected that the teacher will have a hard time teaching the subject as the famous dictum says, "You cannot teach what you do not know." Guimaraes (2014) showed that teachers with greater content knowledge (GCK) have a positive impact on the students' achievement in mathematics. The same result in science was obtained in the study of Diamond and colleagues (2014). In addition, Baumert and Kunter (2013) revealed that teachers with GCK employed higher cognitive-based questions in their teaching than teachers with lesser content knowledge. Further, Rice and Kitchel (2016) declared that teachers with GCK dig more information from students through class discussion and employ more effective art of questioning, unlike teachers of lesser content knowledge that they are inclined to teach more on recall and enumeration. This practice is particularly true with BS Biology graduate teacher and Bachelor of Secondary Education (BSEd) major in Biological Sciences where the BS Biology graduate teacher applies higher-order principles and make the classroom more student-centered than BSEd graduate where the classroom tends to be more teacher-dominated (National Research Council, 2001).

Lifelong Learning Competency

Lifelong learning competency refers to the capability of teachers to learn their responsibility to make their own professional growth and development (Uzunboylu & Selcuk, 2016). Interviewed teachers and administrators mentioned that these skills could



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be drawn out as an essential characteristic that a teacher must have. Admin Jam, a teacher of seven years before being promoted as their schools' SHS Focal Person, believes that a STEM Teacher should be continuously learning since STEM students are smart and wise. As Admin Jam put it,

"When you are a STEM teacher, you are a continuous learner. Once a teacher, always a learner. You must constantly be studying, or else time will come, your students will be smarter than you."

Meanwhile, Teacher Flor believes that learning is a day-by-day activity in teaching to gain knowledge as she admitted, *"Learn every day. Teaching is a journey that will provide you with many opportunities to learn, but you have to be open and willing to take them. I always strive to improve my knowledge every day."*

Also, interviewed teachers shared that they continuously learn by having postgraduate degrees and attending seminars and training. Acquiring postgraduate degrees such as MA/MS and PhD can deepen one's knowledge of the subject and enhance one's skills, most especially in research (Ion & Iucu, 2016). Teacher Maestro is enthusiastic about attending his postgraduate degree as he shared, *"I am engaging in continuous development in this field through taking a Master's Degree major in General Science so that I can be more skilled and knowledgeable."* Aside from getting postgraduate degrees, Teacher Joe shows his lifelong learning competency by attending seminars and workshops as he said, *"I regularly attend division and regional seminars."*



Philippine Normal University National Center for Teacher Education

Also, I participate in STEM-related contests such as research congress. I also do continuing education by getting a PhD."

In addition to acquiring knowledge, all interviewed teachers continuously update themselves on the recent developments and trends in their field of specialization. Teacher Michael stressed this out,

"As a teacher especially in STEM, I make sure to be updated with the latest in the world of Science since this field involves a lot of improvements. I also do a lot of readings and watching the latest videos on the advancements of science. In these ways, I make sure that I maintain my reputation as a good STEM teacher by being updated with what I teach."

Lifelong learning competency deals with the self-initiative of the teachers to learn and update themselves, which is also an essential skill to keep up with the demands of the education system. Lifelong learning is a continuous and long-term process that is progressive and goes over the working life of a teacher (Nicholls, 2010). Lifelong learning for teachers may be in terms of formal education (MA/MS/PhD Program), informal education (reading books, learning from surroundings), and non-formal education (attending training, seminars, or workshops). These formal, informal, and non-formal learnings help teachers to know and abreast the innovations in their field, as well as an avenue of the refinement of their craft (English, 2015). Thus, personal growth and professional development will be ensured among teachers as long as they have the necessary lifelong learning competencies (Artacho et al., 2020; Pilli, Sonmezler, &



Philippine Normal University National Center for Teacher Education

Goktan, 2017). As one instills to the students the importance of becoming lifelong learners, teachers as a model of this paradigm are vital.

Lifelong learning competency is highlighted in the seventh domain of Philippine Professional Standards for Teachers (PPST) which is "Personal Growth and Professional Development." Professional education and the personal life processes of the teachers are valued in this domain as it emphasizes the importance of teachers taking responsibility for their own growth personally and professionally to promote lifelong learning (Philippine National Research Center for Teacher Quality, 2017). The fundamental importance of building life-long learning and well-being is the essence of education. As learning is a process that takes time, dedication, and practice, teachers need lifelong learning competency to update themselves with the knowledge and skills required in their profession. With this practice, the learners will also be nurtured to be holistically developed individuals ideal for nation-building and community partners striving for meaningful change.

Technological Competency

"Education is the most powerful weapon which you can use to change the world." This quotation from Nelson Mandela is a guiding principle because education can alter society in the most significant way. Today, the world is continuously being shaped by rapid technological changes. The metamorphosis of teaching activities such as access to digital connection, technological devices, adaptation of online platforms is a call to challenge every teacher on the responsibility to create learner's efficiency and innovative



Philippine Normal University National Center for Teacher Education

minds who can make an outstanding contribution in strengthening the country's potential. Schools' commitment to transforming their digital pedagogies to flourish in the 21st century and keep themselves active and inventive during these times promote life-long learning opportunities and ensure equitable, inclusive quality education for all (Gomendio, 2017).

Technological competency was discussed by interviewed teachers and administrators. With the advent of the 21st century, students, as well as, teachers are anticipated to utilize technology as means of communication and tools on the access of information. The teachers' technological competencies, also called Information and Communication Technologies (ICT) competencies, play an important role in the STEM curriculum (Raob, Al-Oshaibat, & Lan, 2012).

Technological knowledge and skills are needed as this is part of teachers' instruction in the classroom. Admin Jam highlights this need as she remarked,

“At sa panahon ngayon na isa pa na nakikita kong importante ay dapat ICT literate ka. Kasi hinihingi ng panahon. Dati basta magaling ka lang magturo or marami kang alam, pwede na, but nowadays dapat package, dapat magaling ka din. Hindi man super magaling but at least literate ka pagdating sa ICT (Presently, I viewed the significance that one should be an ICT Literate because it is a societal demand. During the earlier years, mere teaching skills and vast knowledge of information on such topic are enough, but nowadays, one should be “well-packaged” and best, not necessarily excellent but at least on the level of necessary literacy when it comes to ICT areas).”

Technological competency is an important element in helping teachers to bridge the gap between yesterday's and 21st-century values and skills (Zhu et al., 2013). One of



Philippine Normal University National Center for Teacher Education

the three categories of 21st-century skills is literacy skill. Literacy skill pertains to the ability to process facts, digital technology, computation, among others, including information literacy, media literacy, and technology literacy (Zook, 2019). Generally, teachers integrate technology in their teaching to make their classes lively and interactive. Teacher X uses technological tools in his teaching to do this as he shared,

"The good thing about the technology is that it has many websites to choose from which can help us. The interactive approach in the teaching-learning process like PhET simulation is easy to conduct by just inserting it into the lesson. Unfortunately, not everyone can grasp this simulation. However, majority of teachers consider that the materials on the internet are of great support in teaching STEM subjects particularly, Physics."

In other cases, some teachers confide that they are still blank or have a limited understanding of technology integration and know-how. This was disclosed by Teacher Cza when asked how she incorporates technology in classes. She said,

"I know powerpoint and I also teach using video lessons, but in terms of using other platforms and software applications, I do not know. I believe that I am just a beginner with these kinds of digital tools for teaching."

This means that teachers are still a novice in integrating technology in their teaching activities. This scenario leads to teachers' restrictions in using technology for presentations and lesson delivery using videos. This may be attributed to many reasons. Teacher Joe complained about the *"lack of training"* while Teacher Maestro revealed that he could not do it due to *"lack of materials and equipment."* Teacher DeoGirl, who has 35



Philippine Normal University National Center for Teacher Education

years of teaching experience, said that she is hesitant to learn technology since she is *"too old for it."*

Further, she added that she is unmotivated to learn this advanced technology that can help her in teaching. *"Why will I study this new technology? There is no use since I will be retiring soon,"* she explained.

The amalgamation of technology and curriculum gives a social, authentic, innovative, and beneficial pedagogy not only to the students but also to the teachers' technique. This concept is the premise of the SAMR (Substitution-Augmentation-Modification-Remodification) Model in which the strategies in the teaching of teachers are reinvented with the use of technological tools (Falloon, 2020). However, this reinvention will not be achieved if the technological or digital skills of the teachers are lacking. UNESCO through their "ICT Competence Framework for Teachers" enumerated some of the basic technological skills needed by the teacher which include word processor knowledge, graphics software skills, presentation software and other digital resources skills, search engine knowledge and utilization, educational software and online resources integration, communication and collaboration technology skills, and internet safety issue management (Almenara, Tena, & Rodriguez, 2020). These skills are vital as teachers must be capable of using different technology tools to "solve problems, make informed decisions, and generate new knowledge" (Raob et al., 2012, p. 14). Moreover, the technological competencies of teachers will help their students to become decisive, committed, innovative, creative, and collaborative citizens (Almenara et al., 2020). Technological competencies of teachers are highlighted in the COVID19 pandemic when



Philippine Normal University National Center for Teacher Education

face-to-face classes are prohibited. During this pandemic, the technological skills of teachers are put to the test to provide an educational environment where students can still learn and gain knowledge through remote teaching (Portillo et al., 2020). However, studies revealed that the technological competencies of teachers are hindered by the lack of efficacious capacity building in pedagogy and technology (Ghavifekr & Rosdy, 2015; Ivus, Quan, & Snider, 2021; OECD, 2016). Several researchers (Claro et al., 2018; Fulgence, 2020; Perifanou, Economides, & Tzafilkou, 2021; Raob et al., 2012; Saikkonen & Kaarakainen, 2021) noted a dire need for extensive training, adequate time, and sustainable provisions to guarantee that competencies needed and self-confidence in teaching with technology will be achieved.

Research Competency

The research competence of teachers involves their skills in discovering and creating new knowledge. Included in these skills are applying research methods, designing, and conducting studies aligned with the teacher's area of expertise. Through this competency, the teachers can enrich their knowledge of their respective disciplines.

Some participants consider research competency an important skill, but they believe that they are still a novice in this competency, while others feel that they lack research skills. Teacher Jordz admitted that he "*still wanting such competence when conducting some research in mathematics education.*" Delving deeper in the interview, he said that even in action research, he found it hard to do due to time constraints because of overload school work and as he lacks the necessary research skills, it is difficult for



Philippine Normal University National Center for Teacher Education

him to manage a targeted period and task such as choosing research methods and collecting and analyzing data. Teacher Alfred encounters a similar problem as he is also having a hard time conceptualizing a research problem and interpreting the data into a robust result and conclusion. To give a solution to this sad plight of the teachers, Admin Jed in her school encourages her teachers to research since students of STEM Strand do their own research in their Capstone Project as a requirement for graduation. She added,

“Nakakahiya naman na yung mga bata ay nagrereseach pero yung mga teachers, hindi. Para alam nila, kasi baka mamaya mga bata humingi ng tulong sa kanila sa STEM research project, hindi nila alam. (It is an awkward fact that the learners are doing their research but the teachers are doing nothing about it. It is important to engage the teachers therein, to have the knowledge to be ready in a very feasible case that the learners will question or ask help in the STEM research project.)”

A study conducted by Ulla, Barrera, and Acompanado (2017) revealed that secondary teachers in the Philippines have positive attitudes and perceptions towards research. However, factors such as heavy teaching workload (Morales, 2016), lack of research competencies (Ulla et al., 2017), and financial support from the school (Kutlay, 2012) have negative impacts on the secondary teachers to do research. Cortes (2019), through a survey on teacher-researchers in Surigao del Sur, Philippines, found out that there are five research competencies that must be improved and developed, namely "data management, problem conceptualization and resolution planning, appropriate use of data collection tools, application of technology, and research ethics" (p. 15). The adoption of Basic Education Research Agenda within the DepEd System through DepEd Order 39 s.



Philippine Normal University National Center for Teacher Education

2016 which aims to give guidance on the conduct of educational research, is a way for DepEd to inculcate research cultures among teachers and give support on the research funding.

Research competencies serve as scaffolding for teachers' progress in their area of expertise and also in their teaching practice. On PPST, research competency is recognized as an important skill in the second strand of Domain 1 (Content Knowledge and Pedagogy), namely "Research-based knowledge and principles of teaching and learning" (DepEd Order 42 s. 2017). In this strand, teachers must demonstrate understanding and utilize their research skills in teaching and providing knowledge to enhance their practice. Ultimately, this PPST domain hopes that teachers will be *highly proficient* and *distinguished* teachers if they can collaborate and lead other teachers in conducting and applying research to enhance their pedagogy and content. Doing research such as action research improves their research competency, enhancing teachers' self-knowledge, which develops their personal traits and professional characteristics (Morales et al., 2016). This competency also promotes collaboration among their peers and the external community. Studies revealed that research competency enhances and facilitates all other teacher competencies that is why honing this competency is important (Banevičiūtė & Kudinovienė, 2017; Selvi, 2010).

Communication Competency

Communication competence, as a scheme of skills, knowledge, motivational nature, is an integral competence of teachers to deliver an effective teaching-learning



Philippine Normal University National Center for Teacher Education

process. This competence includes verbal and non-verbal communication skills in intrapersonal and interpersonal forms, which provides effective realization of active professional teaching activities (Kasimova & Parfilova, 2020; Nambi, 2019). In the aspect of teacher's training programs to hone expertise in teaching routine, there must be underlying skills in the following fields, such as instructional; academic track content consisting of group relating to cognitive-developmental processes and abilities taken from the offered disciplines; and communication which is the vehicle of all teaching-learning achievement route (Zlatic et al., 2014). As Teacher Michael stated,

"Uhhmmm... for me, there is [a] good and quality instruction in STEM Strand when there is good communication with the students or learners."

Both in the traditional and modern-organized schools, the quality of educational and instructional procedure is judged through the degree of success of communication as proven to be the integral element of teacher-student discourse (Ibrahim et al., 2019). Teachers must be able to convey the instruction without restriction or barrier. With these good communications skills, teachers are always ready to mentor, give advice, and instruct their students which is healthy in the educational system.

Teacher Maestro argued that *"teachers must be good at listening, presenting, speaking, and writing for them to explain things clearly and effectively transmit knowledge to their students."* Teachers become effective when a teacher has deep knowledge and understanding about the subject and can convey it. Even if the teachers have the content knowledge and experience, there will be a problem in achieving 'good



Philippine Normal University National Center for Teacher Education

quality instruction' if the teacher lacks the necessary communication skills (Abid, Hussain, & Shoaib, 2019). Teachers will have a hard time imparting the content knowledge and experience they have. Thus, when achieved together, subject-matter and communication competencies will result in teacher effectiveness (Okoli, 2017). Moreover, a communication-competent teacher can make the class lively and interesting, promoting a good and quality teaching-learning process.

Communication-competent teachers are operative in facilitating learning scenarios particularly in the methodologies on the management as to control the exchange of ideas during the discussion, noise, feedbacks, barriers, environment, or any social interaction reflecting the situations of real-life status which aims to establish constructive conversation to effective teaching-learning episodes (Joynes et al., 2019). The dialogues formed here focus on making learners adapt to social challenges and participate actively in a group influenced by real-life experience and educational operation. Attainment of the teacher's communication competence in the holistic demands in each level of teaching processes and promotion of the socialization scheme of learners at the same time could be achieved in adherence to the goals of instructional procedures (Low, Chong, & Ellis, 2014).

Admin Chard added that a communication-competent teacher establishes a *"positive teacher-student relationship."* Admin Will sees this teacher competence as equally important since the lack of communication skills will serve as a hindrance for him. Effective communication of teachers with the administrators and students will produce a harmonious school environment. Teachers will be able to collaborate well



Philippine Normal University National Center for Teacher Education

with their co-teachers and supervisors if they are communicatively competent (Yusof, Ibrahim, & Rahim, 2017). Teachers who are unwilling to communicate and fail to confront the people around them such as students, co-teachers, and administrators break down trust with them.

Furthermore, teachers' communication competencies can be used to bring out the students' difficulties such as having a hard time understanding the lesson. Moreover, teachers serve as the bridge between students and parents when the former has a problem in school. To successfully discuss the situation of students to the parents, the teacher must be communicatively competent so that the problem will be communicated appropriately.

Listening skill as part of teacher communication competencies is also vital in the teaching-learning process. If the teacher is authoritative and does not give the students or parents a chance to speak, misunderstanding may arise where it can lead to more problems and issues. Thus, a teacher should have the patience to listen to what the students or parents are trying to communicate.

Social-Emotional Competency

Teachers help learners become human with the significance of social-emotional competence. This is the notion of how a teacher's social-emotional competence drives student's success. Teaching is an emotional vocation where social interaction is the key. If we want our students to build their personal and social capability, the stakeholders should support the teacher to model such. The competency has an effect on nurturing positive student-teacher relationships, such as positive attention, positive descriptive



Philippine Normal University National Center for Teacher Education

feedback, noncontingent reinforcement, reciprocal conversation, proximity-playtime, and representation (Patterson, 2014). These are important to learners' social, emotional, and cognitive development. A secure learner-friendly environment helps the youth to secure relationships with peers and other adults. Building such relationships can also reduce the frequency of challenging behavior and increase learners' engagement across contexts (Eccles & Roeser, 2011; Pianta, Hamre, & Allen, 2012).

Teachers who are targeting the affective domain of teaching are expected to establish a kind of climate that is "caring, nurturing, supporting and encouraging" for the learners (Hornstra et al., 2015). The climate must invite opportunities for learners to show their best-self in doing academic pursuits and how they will react acceptably on values-formation rules given by the teacher, school, and society. Moreover, such a climate will help teachers decide and work with motivation management of learners, mentoring on handling conflict circumstances, and promoting teamwork on the concept of students' belongingness in the place where they are expected to practice good comportment socially and emotionally (Burusic, 2019).

Selvi (2010) defined teachers' emotional competencies as competencies consisting of empathy, morals, values, attitudes, anxieties, beliefs, and so on. Meanwhile, social competencies involve interpersonal skills, the outlook of the teachers to themselves, self-decisions, self-confidence, and understanding others (Dubovicki & Brust Nemet, 2015). This includes teachers' innate characteristics such as being a model, mentor, and character flexibility. Most of the participants described that teachers in teaching should be committed, passionate, engaging, open-minded, friendly, confident, and approachable. In



Philippine Normal University National Center for Teacher Education

addition, teachers should be motivators and molders as part of their social-emotional competence. Admin Jam described,

"If you are a good STEM teacher, you should also be a motivator. It is important that you motivate your learners to bring out what else they have because once they enrol in STEM, there is so much they can do. The teacher just needs to push his or her student to perform. Most importantly, when you are a STEM teacher, you mold your student not only to have a lot of knowledge on the subject matter but to have a good attitude."

Another perspective from the interviewed administrators was taken. They believed that teachers in the STEM Strand should have strong work ethics, be motivated, critical thinkers, problem solvers, innovators, creative, responsible, always ready and prepared. They believe that STEM students are special and highly intelligent. It is essential to note the statement of Admin Armier. She reiterated that personal characteristics *"like enthusiasm, motivation to teach the course, and probably the passion, love for the subject must be inherent to the teacher."*

The researcher has also collected an interesting view from the interviews that part of teachers' social competence is being a student model. Thus, teachers are expected by STEM administrators to have academic excellence and qualities of being similar to a scientist, mathematician, or engineer. As Teacher Bart, a Physics Teacher shared,

"With regard to my characteristics, of course, academic excellence is important in the STEM field because remember, we are teaching STEM students who are future scientists of this country. Thus, we need to act like a scientist. So, I think academic excellence and an attitude like a scientist are very important, especially if you would like to make your students excel in their field."



Philippine Normal University National Center for Teacher Education

Some participants have the same opinion with Teacher Bart that a teacher should be like a mathematician or scientist or an engineer so that students will acquire this attitude for them to be a better future STEM workforce in the country. This portrayal is very important as Morrison (2018) revealed that many students are more inclined to take STEM courses in their college when their teachers show them proper laboratory skills and teachers conduct experiments like a scientist.

Teachers need to be socially-emotional because they guide students toward the right path. They also play a role in helping to develop the good morals of the students. According to studies, teachers' social-emotional competencies could help students' motivation and willingness to learn (Gedvilienė, 2015; Lane, Pierson, & Givner, 2004). Social-emotional competent teachers could deliver positive support for the teaching-learning process as this translates into the social-emotional aspects of learning of students (Saudagar, 2019).

3. Teacher Pedagogical Characters

The third construct that the STEM administrators and teachers described in the interviews is the themed, pedagogical characters of the teachers. Teachers' pedagogical characters are based on their ideas and thinking which are demonstrated mainly in their teaching practices and overall pedagogical strategies. Their pedagogical characteristics are manifested from the types of learning and teaching the teachers experienced when they were students, the teaching strategies learned during formal education, seminars, and workshops, and those emulated from other colleagues (Sasson, 2018). These pedagogical



Philippine Normal University National Center for Teacher Education

characteristics became the teachers' dispositions on their teaching approach, such as how they want to impart knowledge to their students and how they will seek participation from students in the classroom. Significantly, these characteristics were used by teachers on how the students want to see themselves in a classroom and on what role they will play in the teaching-learning process (Reyes et al., 2020; Wengrowicz, 2014).

Figure 27 shows the three pedagogical characters deduced from the interviewees' responses along with the pedagogy techniques used in each character. Based on the pedagogies employed by the teacher-interviewees, the following define the pedagogical characters of the participants: *communicating teacher*, *engaging teacher*, and *transforming teacher*.

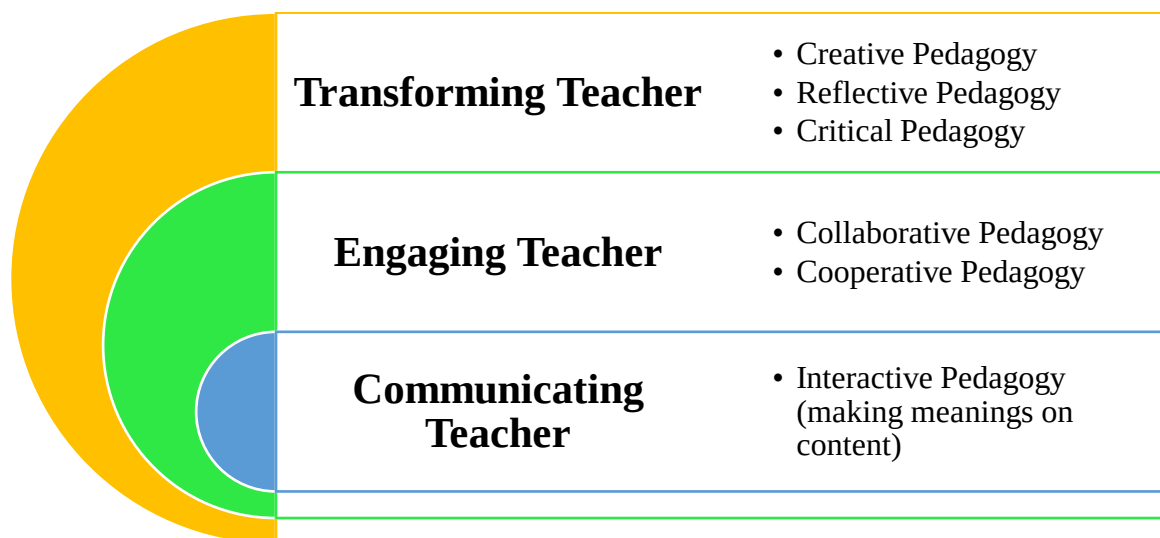


Figure 27. *The Pedagogical Characters of the STEM Teachers*



Philippine Normal University National Center for Teacher Education

Figure 27 shows a unique relationship among the three pedagogical characters. Notice that the *communicating teacher* shares the subordinating character of the *engaging teacher*. On the other hand, the two said pedagogical characters would be seen to be under the principal character of the *transforming teacher*.

Communicating Teacher

Many students felt that science concepts are hard to understand. They found the concepts and ideas complex, abstract, and dynamic in nature. In addition, students have some misconceptions in science that are difficult to change. The difficulties that the students' experiences and misconceptions affect teachers' pedagogy; thus, science teachers gave more effort in teaching the subject than other teachers teaching a different subject (Tompo, Ahmad, & Muris, 2016). To unlock the difficulties and the wide range of misconceptions of the students in the subject, science teachers utilize an effective communication strategy to develop and build new knowledge easily comprehensible to the students.

As discussed in the communication competency (see Teachers' Competencies), teachers must exhibit expertise in communication approaches when one is establishing a conducive school environment. Communication approaches are the so-called writing, reading, speaking, and listening, and these are used to achieve students' success in the academic challenges, likewise, to teacher's professional success (Khan et al., 2017; Muste, 2016). Communication skills are the life of teaching procedure and call the teacher's responsibility to make the diverse information into a simple, comprehensive,



Philippine Normal University National Center for Teacher Education

and contextualized to the student's level of engagement both in non-verbal and verbal forms (Hoon, Nasaruddin, & Singh, 2017).

Communicating Teachers use the aforementioned communication skills to effectively transmit and explain the information to their students. Teacher Flor, a biology teacher, admitted that she uses the lecture-discussion method most of the time to communicate the information in her subject. According to her, "Biology is a subject which is memorizing in nature." She explained that biology is factual, thus, she uses the lecture-discussion method to effectively incorporate the knowledge to the students. Another teacher also used the lecture method more often because there are many topics in his subjects that need careful analyses and clarity of the content. Thus, he believes that data and information are sacrosanct in this subject and must be transmitted to the students in the given time. He acknowledges that using the lecture method is the quickest way to teach all these necessary contents given the limited time. The mode raised here influences some qualities of an effective teacher who is specialized both in academic knowledge and the manner of communication to be used in the field. The communication competency must be solidarily injected with the pedagogical skills and discipline mastery for a more in-depth exploration of teaching practice and learning experience. This is contrary to the features of teachers' traditional teaching model which is limited to subject matter mastery and pedagogical skills which are determined throughout the entire school year, thus, a minor role communication process between teacher and students.

The teacher is the active source of purposive communication to convey information, elucidate issues, explain complex or ambiguous data, contextualize theories,



Philippine Normal University National Center for Teacher Education

and promote student's responses in any form which may build effective communicative experience as a stimulus to observe varied behaviors (Yusof & Halim, 2014). These are the objectives and goals of Communicating teachers.

Communicating Teachers in the interview imparted that they use Interactive Pedagogy more often in their class discussion. The interactive pedagogy makes students active agents in making significance in the instructional content they are engaged in. Learners are given a set of learning opportunities so that they can execute what they have acquired. In this way, they are deemed to be responsible for the process known as making meanings (Tadesse et al., 2021). Making meaning is one way of remembering ideas after fully engaging and practicing the learning objectives on a long-term basis. Another good point on making meaning is that it liberates the students to understand the lesson by describing and coming up with a new notion and then demonstrating it to practical situations (Guthrie & McCracken, 2010). Thus, the teacher should support the link between the newly formed ideas taken from the raw information and the action. To give a concrete detail during the teaching-learning process inside the classroom, the practice of communication skills of students is tested and the mental process is expected for more exploration of ideas introduced by the teacher. The learners who developed multiple and working perspectives are ready to demonstrate their social and emotional skills.

Engaging Teacher

A teacher should exhibit a personality that is a stimulus to an active learning engagement of the students. This strategy is a cure to lessen or avoid the increasing



Philippine Normal University National Center for Teacher Education

numbers of unmotivated students since learners will have a strong invitation of their curiosity to learn. Engaging teachers maintain and develop a positive attitude in the learning environment, which can be seen on teaching assessment, working relationships with colleagues, improving students' performance, and establishing better classroom conduct.

The interview revealed that engaging teachers use collaborative and cooperative pedagogy in their teaching strategy. Collaborative pedagogy is the set of teaching strategies and techniques encouraging students' collaboration to improve their "own and each other's learning" (Le, Janssen, & Wubbels, 2017). Meanwhile, cooperative pedagogy is the teaching process wherein the students are learning together with the help of each other in a small group (Singh & Agrawal, 2011). While used interchangeably, collaborative and cooperative pedagogies differ mostly on the roles of the teacher between the two. Collaborative pedagogy focuses on students' engagement and limits the role of teachers to the assistance in the classroom activities only if necessary. In collaborative pedagogy, students create their own materials and procedures for the activity and assess their own performance development and progress whether individual or group tasks. The activities are commonly group-structured and students will decide on the tasks they will do since the success of their performance depends on their strengths (Loes & Pascarella, 2017). On the other hand, cooperative pedagogy involves activities in which teachers mostly decide on the role of students. Teachers give the information to students on how the latter will do the activities and how teachers can intervene and observe their work. Students will submit their finished output to their teacher for



Philippine Normal University National Center for Teacher Education

evaluation, thus, each student will be graded according to the exerted effort in every task given (Sawyer & Obeid, 2017).

Most of the interviewed teachers claimed that they use collaborative and cooperative pedagogies frequently in their teaching. They want to ensure maximum participation in class discussions and group activities. Teacher Maestro promotes collaborative learning in his class so that his "*students will surely learn and appreciate the knowledge they want to achieve.*" Meanwhile, Teacher X uses collaborative pedagogy so that students from other schools will be at the same level in terms of knowledge as the students who finished their Junior High School from the same school Teacher X teaches. He noted that there is a big discrepancy in the students in terms of their level of knowledge toward his subject, Physics. This discrepancy may be attributed to the fact that there were additional subjects in private Higher Education Institution (HEI) where Teacher X teaches compared to the offerings from DepEd schools. He narrated,

"When my topic needs advanced mathematics, I used a collaborative approach. I bring students together. The students who came from other schools were grouped with our former students. So from there, they can learn from our students, they can collaborate, teach others, and have shared ideas. It is super effective based on my experience."

On the other hand, Teacher Pooh uses cooperative learning as an avenue of active participation in the class. She grouped them according to different styles of learning such as auditory, visual, and kinesthetic. She added that she grouped the students according to their abilities like slow, fast, and average learners. Using this style, she ensures that there



Philippine Normal University National Center for Teacher Education

will be no dominating person in the group. She also uses gamification as a technique to foster collaboration in her classes. Thus, games like Sumobot, where students will program their robots to act like sumo, are common in her class in Robotics. She explained,

"I also enjoy when I saw my students having fun in doing Sumobot. Having fun while learning is a great feeling for the students, even for teachers like me."

Educators, specifically engaging teachers, have known the benefits and advantages of having a collaborative and cooperative environment in shaping the students' minds a long time ago. Studies revealed that students who were engaged in cooperative learning exhibited better performance in academics than students who were not engaged in cooperative learning (Decuyper, Dochy, & Van den Bossche, 2010; Kumar, 2017; Puzio & Colby, 2013). This is also in consonance with the studies of Chatila and Husseiny (2017) and Bowen (2000) that the use of cooperative pedagogy enhances achievement in biology and chemistry, particularly for secondary and college students. These studies revealed that engaging teachers rely on students' active participation and are more leaned towards student-centered activities rather than teacher-centered activities. Moreover, deeper cognitive tasks and better-shared learning experiences are advocated by engaging teachers to promote team-building skills and encourage social interaction among their students (Caswell & LaBrie, 2017; Wells, 2016). Thus, engaging teachers enhance the social skills of the students as cooperative



Philippine Normal University National Center for Teacher Education

and collaborative pedagogies require teamwork to successfully finish an activity. STEM students may simulate this type of environment as they enter the workforce since teamwork is a common task when they have their job. Innovations are also more fruitful with collaborations. The dictum, "Two brains are better than one," seems appropriate in this case. Innovation is an output of many minds having shared ideas and objectives rather than a person who highly regards himself as all-knowing.

All interviewed STEM Administrators believe that engaging teachers should be the minimum characteristic of a teacher in terms of pedagogical characters in teaching the STEM Strand. They also want a classroom with the teachers and students proactively learning together. According to the STEM Administrators, the traditional teaching, wherein the teachers are the authoritative source of knowledge is now considered obsolete.

"They have their own ways of engaging the students how to be active in the learning context because it is really must for them and I believe they know it and they claim it to be their mandate. It has become an obligation of the teacher to make the learning active and engaging. Because if they don't, we will not really expect good results. The school really operates with that scheme. That is the teacher's main responsibility to deliver the lesson the way that it is engaging and that the students would become active learners." (Admin Spiderwoman)

Transforming Teachers

The last pedagogical character derived from the interviews is the *transforming teacher*. The researcher considers this character to be the highest level of pedagogical characteristic teachers may have as they are the teachers who use mostly the highest



Philippine Normal University National Center for Teacher Education

levels of Bloom's Taxonomy of Learning Domains such as creating, evaluating, and analyzing in their teaching-learning process. Thus, they are the teachers who mostly use reflective, creative, and critical pedagogy in the classroom. Even though all the interviewed teachers utilize these pedagogies, only a few teachers claimed they use them entirely or mostly throughout their teaching in the STEM Strand.

Interviewed transforming teachers revealed that they integrate activities, experiments, and tasks related to the lesson to help the students to appreciate the lesson and to relate to the real-life problems or scenarios. By asking more profound questions, they want the students to reflect more on the lessons, what they have learned, and how they will use and apply the information in their context. They employ reflective pedagogies by providing structured assignments, as well as active discussions to embed meanings from the experiential-based learning of the students. They ensure that their students can relate to the lesson even in the student's day-to-day living. Through this technique, transforming teachers claim that they give authentic learning to the students.

Transforming teachers are also concerned about what their students can create in their lessons. By integrating creative pedagogy, they like to bring out the creativity and innovativeness of their students. Aleinikov (2013) defined creative pedagogy as a strategy that "teaches learners how to learn creatively and become creators of themselves and creators of their future" (p. 327). Interviewed teachers apply this technique to know how creative the students are in relation to their learning. Teacher Michael narrated,

"I let my students suggest different things in our lesson since those kids are already mature. So, every time they do experiments or do classroom



Philippine Normal University National Center for Teacher Education

activities, I only give the objective of the activity and I let them suggest what they want to do. For example, Sir, in our Physics activities in parabolic motions. Instead of providing an improvised device, I let them suggest what they want to use to make a parabola."

Interviewed transforming teachers are more concerned with bringing out the students' higher-order thinking skills by giving reflective and creative activities. The students are provided with activities that will lead them in the discovery of learning. Also, they want to develop the students' critical thinking skills, another higher-order thinking skill, by using critical pedagogical techniques. Transforming teachers want their students to learn the societal importance of learning. The interview corpus revealed that transforming teachers want the learning of the students more relevant by integrating societal issues in their classroom teaching. The transforming teachers, as well as some administrators, wanted to "empower" their students in the community by discussing the problems of the community and its possible solutions. The role of the students in the community as participatory is highly advocated. Through this, students will understand their position in society and can explore positive steps to know their identity in the community. Societal and community issue discussions and debates were common activities in their class interaction.

Paulo Freire, considered to be the most famous proponent of critical pedagogy, emphasized the role of critical thinking in the removal of societal injustices and discrimination (Razzak, 2020). In his book, *Pedagogy of the Oppressed*, Freire asserted the importance of school as a place for social change and community evolution



Philippine Normal University National Center for Teacher Education

(Mahmoudi, Khoshnood, & Babai, 2014). The use of critical pedagogy enhances students' sociocultural knowledge. Self-actualization and self-awareness of students to achieve a better surrounding are expected to enhance in this pedagogy (Mclaren, 2020). Critical pedagogy could equip students' skills for their advocacy on environmental concerns and social justice. On the other hand, teachers who use critical pedagogy need collaborative partnerships, sharing resources, and critical reflection tools (Daly-Lesch, 2019).

Dasas (2020), in his study, revealed that science teachers in the Philippines already integrate critical pedagogy in their classroom teaching for contextualization and indigenization. Although beginning teachers (fresh graduates) see themselves as highly critical in utilizing critical pedagogy in the classroom, their understanding of critical pedagogy is proven to be shallow. The study also revealed that experienced teachers (with more than five years of teaching experience) and administrators perceived critical pedagogy as a strategy that makes learning more relevant to the students.

4. STEM Curriculum

In 2013, an educational reform was implemented in the Philippine basic education aligned with the following objectives: the curriculum be decongested; the students be more prepared in higher education; the students be empowered and equipped for the labor market; and the country's education be compliant with the global standards (Magno, 2011; Yap, 2011). This educational reform is now known as the K to 12 Enhanced Basic Education Curriculum. This new curriculum is in accordance with Section 2 (1) of Article



Philippine Normal University National Center for Teacher Education

XIV (Education, Science and Technology, Arts, Culture and Sports) of the 1987 Philippine Constitution which states that *"The State shall establish, maintain and support a complete, adequate and integrated system of education relevant to the needs of the people and society."*

Additionally, the new curriculum created another level of basic education known as the senior high school (SHS) program, expanding the length of the schooling from 10 years to 12 years of formal schooling. This curriculum hopes to produce holistically developed individuals fortified with 21st-century skills which are essential for life-long learning and job opportunities for globalization. Through this curriculum, the government hopes that quality assurance in education will be achieved as part of the Philippine Qualifications Framework.

The STEM curriculum under the K to 12 program is founded on educating students in four specific disciplines – Technology, Science, Engineering, and Mathematics. This curriculum is designed for the science, math, and technologically-inclined students to strengthen their ability to integrate and apply their knowledge and skills, thereby becoming useful citizens in the future. Also, the pipeline of the STEM workforce will be ensured through the STEM curriculum by producing capable students that will take courses in STEM fields such as physics, chemistry, engineering, mathematics, biology, among others. Since the K to 12 was enacted for the past eight years, the STEM curriculum has been considered vital for the Philippine Science Education Framework.



In the study, teachers and administrators gave contrasting answers when asked to describe the current STEM curriculum. Some are good descriptions of the curriculum, while some share their negative experiences. Three sub themes were formed from these contrasting answers: *comprehensive yet congested*, *work-oriented yet very idealistic*, and *well-designed yet problematic*, as shown in Figure 28.

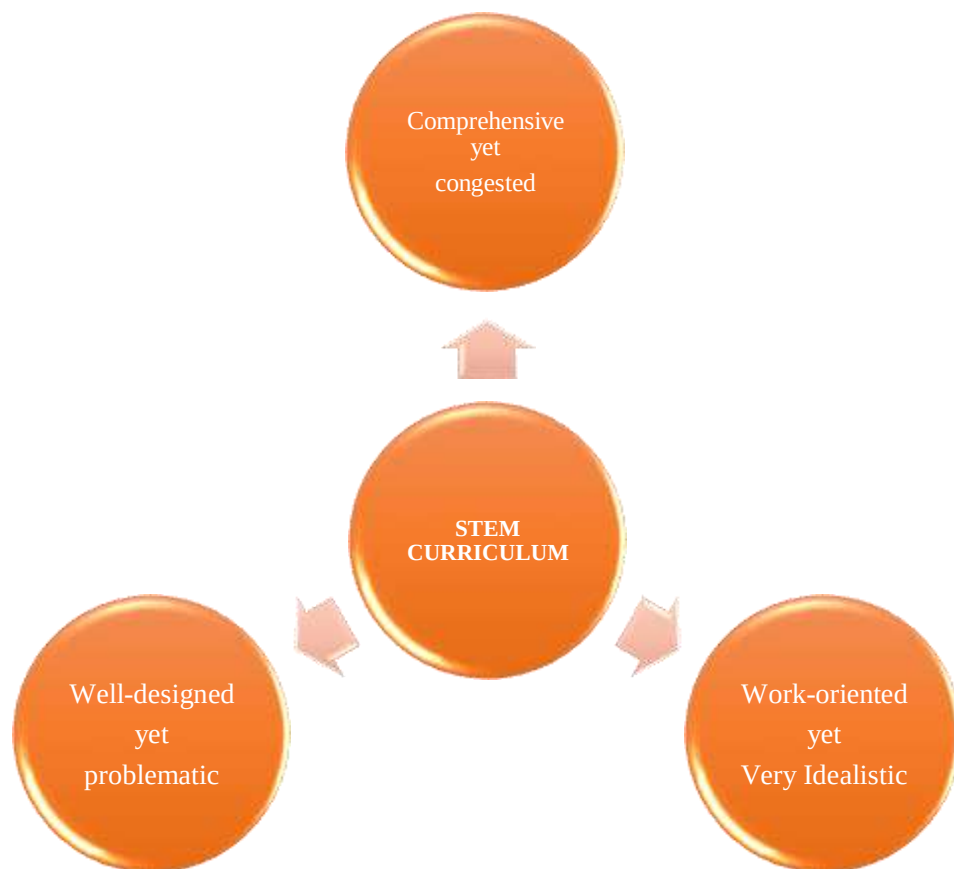


Figure 28. Descriptions of the interviewees on the present STEM curriculum.



Philippine Normal University National Center for Teacher Education

Comprehensive yet congested

Interviewed teachers claim that the STEM curriculum at present is comprehensive. Teacher Maestro claims that the curriculum is comprehensive enough for the students since all the necessary subjects are there which can develop their skills especially in doing research. According to him, students are being exposed to social and experimental research since they have Practical Research 1 and 2. Likewise, they have the subject Inquiries, Investigations, and Immersions (3Is) in which their scientific skills are enhanced and capstone research that showcases their talent and skills in doing a scientific research study. He concluded,

"Through these subjects, I can say that students graduated from STEM Strand are fully equipped and knowledgeable in terms of scientific skills, attitudes, and talents."

This is similar to the idea of Admin Sensei since she believed that every Science and Math subjects in the STEM Strand is perfectly planned. Other administrators believe that each subject's content and performance standards are crafted with a comprehensiveness that could meet the global standards. In addition, the quality or degree of proficiency, as well as competency in a particular learning area aligned with the standards, was assured through the curriculum. This alignment shows how the curriculum is articulated in competencies and standards.

The curriculum has the following learning standards: learning competencies, performance standards, content standards, learning area standards per grade level, and key stage standards. These standards include the set of skills and knowledge that the



Philippine Normal University National Center for Teacher Education

student must obtain or perform based on the content and task. The curriculum sets these standards as the "reference point for planning teaching and learning programs and assessing student progress" as stipulated in DepEd Order No. 21, s. 2019 titled "Policy Guidelines on K to 12 Basic Education Program."

Teacher Alfred also stated the attributes of the curriculum comprehensiveness to the specialized subject. The specialized subject encompasses all the necessary knowledge and skills for the chosen track of the students. It contains competencies and content that is only provided in the STEM Strand. He stated that the specialized subjects could be a good foundation and boost the students' interest to take STEM-related courses. Teacher Cza has the same idea about this. According to her, *"the specialized subjects will really prepare them for the future."* STEM Curriculum is composed of Core, Specialized, and Applied Subjects. Overall, there are 31 subjects distributed in four semesters or two years. There are two quarters per semester which account for 2,480 hours of learning of a student in SHS. With these 2,480 hours, each subject has 80 hours allotment per semester except PE and Health, which have 20 hours allotment per semester. The STEM Strand contains highly specialized subjects in relation to the STEM fields. These subjects are Precalculus, General Chemistry 1 and 2, General Physics 1 and 2, General Biology 1 and 2, and Basic Calculus.

However, even though the STEM Curriculum is comprehensive, the teachers, as well as, the administrators believe that the curriculum is congested. They shared that the curriculum is somewhat heavy in content. It is in contrast with one of the major aims of the K to 12 Basic Education Program which is to decongest the curriculum. Interviewees



Philippine Normal University National Center for Teacher Education

who are teaching Physics similarly assessed the STEM Curriculum as congested. The same feedback was gathered from interviewees teaching Chemistry. It is in a sense congested because there are many topics in the curriculum guide that are not possible to finish for the whole school year. This issue is experienced by interviewed teachers teaching mathematics, chemistry, and physics. Teacher Bart admitted,

"For more or less four years now that I was teaching Physics in the STEM Strand, not even once that I was able to finish the scope of the lessons for this subject. I will tell you truthfully, there are many competencies that I did not cover. This is because the subject is congested in topics due to limited time."

On the other hand, one Biology teacher said that she successfully covered all the lessons. However, as the researcher delved deeper during the interview, she revealed that she skipped some topics. Other Biology Teachers also shared that they are doing the same practice of skipping topics just to finish the topics intended in the subject. Admin Jam also has the same predicament in their division. According to her, finishing the content of physics and chemistry in a school year is a problem because from the first year of implementation of the STEM Strand up to the present, there are too many topics. For the Calculus and Biology teachers in her school, the problem is solved when they skip topics or by integrating content standards or competencies into one. She added,

"The content of Physics and Chemistry as being too many in content is the feedback of other STEM teachers who are part of our division. I have already attended two year-end Senior High School implementation reviews and the feedback of STEM teachers in our division is consistent."



Philippine Normal University National Center for Teacher Education

The curriculum guide for STEM Strand especially in Physics and Chemistry is too much loaded."

Some teachers attributed the curriculum congestion to the repeated topics. For them, there are certain topics that are already in Junior High School repeated in Senior High School. They believe that this repetition only takes time which affects the development of the lesson in the STEM Strand.

Even though they appreciate the spiralling of topics in science done in JHS then by area or branch of science subjects in SHS, they believe that improvement must be made so that repetition of topics will be avoided. Teacher Michael shared,

"Right now Sir in the Senior High, I think Sir it is still too much content. The curriculum is congested. It seems like there are still many topics that can be removed. Sometimes the topics even overlap. The topics of Grade 9 and Grade 10 are repeated in the Senior High School. There seems to be a repetition."

This is also the same sentiment of Teacher DeoGirl,

"It is spiral but it is repeated sometimes. There are topics that have been tackled that you will discuss again. I think it needs synchronization."

As a key feature of the curriculum, the spiral progression approach attempts to introduce concepts at an early phase and deepen them as the students move up to another grade level (de Ramos – Samala, 2018). With such, K to 12 curriculum developers expect that mastery of the subject matter and skills will be attained. However, in his study, Victorino (2019) observed the seeming disjoint between junior high school science and



Philippine Normal University National Center for Teacher Education

mathematics with that of SHS. This disjoint resulted in the repetition of topics and misalignment of the spiralling of the topics in these subject areas. This problem is observed by Teacher Alfred in his subject,

"Spiralling of science topics in JHS is one of the problems. It is a spiral of biology, earth science, physics, and chemistry, but those spiral progression does not lead to mastery of the content of the students. When they enter the SHS, the student is awed because there is no mastery. And at the beginning of the lesson for example in chemistry, the student does not know balancing chemical equations that they should learn from their junior high."

The same observation is noted by Teacher Joe especially in the lessons on acid-base chemistry. JHS students learned about the acid and base mostly through examples and basic definitions in Grade 7 then its properties in Grade 10. However, the complexities leaped when acid-base titration was introduced in Grade 11. He stressed that equilibrium concentration, pKa, calculation of pH, and Henderson-Hasselbach equation must be explained first before teaching acid-base titration. Teacher Joe explained,

"Some of the requisite knowledge for SHS topics were not provided in the JHS. The students will not understand the topics in SHS without these fundamentals. Thus, we add more topics to fill this gap, but we sacrifice other topics with this process. Adding fundamental topics with the already congested subject is a difficult task for teachers."

Interviewed Physics and Mathematics teachers also experienced this problem. Further, the number of subjects adds to the students' difficulties in obtaining all the competencies provided in the curriculum. For the teachers, eight core subjects and two



Philippine Normal University National Center for Teacher Education

specialized subjects in a semester are too many for the students to handle. For these reasons, teachers believe that students are too tired since they are bombarded with so many subjects. Teacher Michael stressed that students find it difficult to process information because of the quantity of the topics and the number of subjects in a quarter.

Work-oriented yet very idealistic

The interviewees unanimously agreed that the curriculum is work-oriented. The two years of SHS STEM Strand are expected to prepare and train the learners with craft and skills that will equip them for entrepreneurship, employment, higher education, or skills development in STEM fields. Curriculum planners foresee that students could apply for a job related to their chosen track after graduation from SHS. Teachers and administrators believe that the content of the curriculum in the STEM strand is made to prepare students for different science and engineering activities and procedures. The activities will enable learners to apply their skills in real-life settings. This provision allows contextualized practice for the students in applying their obtained 21st Century Skills in the strand (Dumapias & Tabuzo, 2018). This is in consonance with the curriculum planners' objective to empower and equip students for the labor market. With such, the students will make an impact on the aspect of the economic and social development of the community. In addition, they believe that the curriculum ensures that the subjects will be relevant and proper so that the skills will be attained and students could have a job even though they are only senior high school graduates. The work orientation of the curriculum can be seen by examining the subjects. Teachers appreciate



Philippine Normal University National Center for Teacher Education

the fact that the first three of the four semesters (two years) of the students in SHS are dedicated to equipping the students with the necessary skills and knowledge on STEM subjects. Then, these skills and knowledge will be put to the test on the subject, *Work Immersion*, in the fourth quarter or last semester of the SHS. Work Immersion exposed the students to become accustomed to work that is related to their area of expertise or specialization to improve their skills, capability, and aptitude for at least 80 hours. Additionally, Work Immersion is expected to “empower learners to identify and solve complex problems, to encourage them to think independently; to work with teams, and to exhibit the traits of leaders no matter what their job in an organization” (DepEd Order No. 30, s. 2017). Students who will be in work immersion are expected to be guided by STEM professionals to gain the practical and relevant skills related to STEM fields. Moreover, it aims to develop good work etiquettes of the students. This enrichment with the highlight on the work experiences and skills of the students better equips them to be STEM professionals.

However, the interviewees noted that the curriculum is very idealistic. Some interviewed teachers and administrators described the curriculum as ‘ambitious.’ As Teacher Alfred mentioned, the phase of the curriculum guide is rigid as if there will be no class interruption. This is a source of the problem because teachers tend to skip important lessons to follow the lessons prescribed in the curriculum guide. Also, as the curriculum planners make the STEM curriculum best for all, they seem to forget the receiver of the curriculum -- the students of diverse backgrounds, which impacts the curriculum. The STEM teachers want to achieve, comply, and deliver the contents incorporated in the



Philippine Normal University National Center for Teacher Education

curriculum to the students. But the problems arise when students find the kind of implementation difficult, thereby making teachers allot more time for the topic. This adjustment will slow the pacing of the teachers and the schedule might be affected. In the end, the topics included in the curriculum, especially the latter part, will not be finished. This will have a domino effect on the scheduling. Furthermore, the complexities of the subject make it difficult for the student to understand the topics. Teacher Flor stressed,

“Program outcomes or skills of the curriculum provided idealistic goals that are hard and almost impossible to achieve given their age, the resources, and opportunities.”

Well-designed yet problematic

The administrators and teachers believe that the curriculum is well-designed for the students who will take courses in the STEM fields. They acknowledged that the STEM Strand aims to prepare and encourage senior high school students to take science-related courses at their tertiary level. The STEM Curriculum contains subjects that will supplement the necessary information and knowledge for their future pursuit in STEM-related courses that can be used in their everyday lives. The skills that they will gain during their stay in the STEM strand will help them prepare as future STEM workforce of the country. Admin Jed explained, *“It is complete and I feel it is really planned and studied to form our curriculum, for the subjects to be adjusted and to make the substance more appropriate.”*



Philippine Normal University National Center for Teacher Education

The curriculum is designed for students who will take up engineering, biology, physics, and other science-related courses. This was observed by the teachers and administrators as the majority of their students took science-related courses at the tertiary level.

“Our STEM graduates enrolled in STEM-related courses in college like Nursing, Engineering and some other related science disciplines. Their present college or university reinforces their prior knowledge that they acquire in SHS.” - Teacher Maestro

“Many of the STEM graduates are pursuing Science courses, Engineering courses, and Mathematics courses. They find their courses are the fields needed in our society.” - Teacher Jordz

“Our graduates are taking college courses under STEM Fields. They take courses that will lead them to become a scientist.” - Teacher DeoGirl

Another feature of the curriculum is the key stages. In the K to 12 program of the Philippine Basic Education, there are four key stages namely “Key Stage 1 (Kindergarten to Grade 3), Key Stage 2 (Grade 4 to Grade 6), Key Stage 3 (Grade 7 to Grade 10), and Key Stage 4 (Grade 11 to Grade 12)” (DepEd Order No. 21 s. 2019, p. 4). The interviewed STEM teachers and administrators noted that through these stages, the arrangement of the subject matter is well-defined and logical. Through this arrangement, the review and the reinforcement of learning are maintained throughout the key stages. With these stages, interviewed teachers and administrators observe the compliance with the international standards and with that of higher education. The Department of Education ensures that the K to 12 curriculum is aligned with the New General Education



Philippine Normal University National Center for Teacher Education

Curriculum for Higher Education of CHed. DepEd believes that through this curriculum, the standards will be at par not only with the basic education curricula of Asia-Pacific countries but also with the global standards.

From the perspective of teachers and administrators, since the curriculum is well-designed, the STEM curriculum is responsive to the needs of the society --- the demand for an additional STEM workforce in the country. The STEM strand is envisioned to be the answer to the perennial problem of the country on the lack of science and mathematics practitioners and with such, an increase in the STEM professionals in the Philippines is expected (Estonanto, 2017).

However, it is noted that the curriculum seems problematic as they listed some challenges in their teaching. First is the lack of the teachers' and students' guide for specialized subjects. Physics teachers complained that they do not have students or teachers' guides unlike mathematics and biology. For chemistry, there is a student manual but no teacher's guide. Even though there are books in JHS, no textbook or learning resource is provided in SHS for specialized subjects. Teachers only follow the curriculum guide provided by the DepEd and for them, it is not sufficient. Interviewed administrators claim that teachers are blank on the materials and teaching resources for their instruction. The lack of science textbooks has been a persistent problem in the country (Tupas & Matsuuraa, 2011). Francisco (2019) observed that since 2016, no textbook for STEM strands has been distributed or available in public schools in the entire country. Even though private schools have the option to purchase textbooks from publishers such as Phoenix, Diwa, Rex, and C & E Publishing Company, this has proved to be costly for the



Philippine Normal University National Center for Teacher Education

students and teachers. In the study of Tupas and Matsuraa (2019), they found out that the “absence of textbooks in teaching senior high school affects learning as well as time allotment” (p. 413).

The second challenge is that the provision of materials and equipment is inadequate. Interviewed teachers shared that they cannot perform experiments since no chemical reagents and equipment are available, especially in public schools. Even though teachers still make a way to conduct the experiment by being resourceful, they claim that it is still different if the experiment is done using the intended or specified materials. Some teachers admitted that the DepEd provided some equipment and materials but in a staggered distribution. The sad thing is that it is given in such a small quantity that the teachers ought to perform the experiment in a demonstration using these limited materials rather than in groups. Teacher Bart remarked, *“Students would have learned better if the experiment was done in groups. Acquisition of competencies and practical skills inherent in the laboratory experiments will be ensured if the materials are enough.”*

For the equipment, their main concern is that they do not know how to use the resources properly and some are even not appropriate for their subject. This issue is also the same concern of interviewed administrators since these resources are just put into shelves and the utilization is not maximized because the teachers are not equipped to manipulate the equipment. They felt that these resources were put to waste. Teacher Maestro shared,

“The Division Office gave us five graphing calculators that could be used to interpret data and for data visualization. But I did not demonstrate or



Philippine Normal University National Center for Teacher Education

show it in the class even once since I do not know how to use it. There are so many buttons and functions that I am unfamiliar with. I hope there is training for the teachers on how to use it.”

This is also the experience of Teacher Flor when DepEd provided an Autoclave, an instrument used for decontamination and sterilization of laboratory apparatuses from microorganisms, in their school. She narrated that the equipment was only delivered to the school but no training or demonstration on how to use the equipment was conducted. Teacher Flor admitted that she has no prior experience in using an Autoclave even during her college years. Even though there is a manual, she is hesitant to use it for fear of damaging the equipment. She expects that there is a training or demonstration, but for two years now, there has been none. Thus, they could not use the Autoclave in laboratory activities or experiments. She added, *“We only display the Autoclave during our Science Fair.”*

The very big challenge that the interviewees mentioned in their teaching is the lack of laboratory rooms. Admin Sensei insisted that not every school can afford to provide a laboratory that is needed for each subject, especially in science. Admin Spiderwoman stated that the lack of laboratory facilities hinders the efficient attainment of students in terms of performance and content standards prescribed in the curriculum. Admin Rina has expressed the same concern on the need for functional laboratories so that students can have mastery of the content and its application. Teacher Maestro shared that even though they have a laboratory room in their school, he is concerned that the laboratory caters to all the science subjects and materials at the same time. The laboratory



Philippine Normal University National Center for Teacher Education

is a Physics Lab, Chemistry Lab, and Biology Laboratory simultaneously. He argued that each subject must have separate laboratories. When the researcher asked what happened to the other laboratories, he shared that some laboratories were converted into classrooms or offices because of the lack of buildings that can be used in teaching. For HEI, some interviewed teachers replied that college students and SHS Students share the laboratory. There are instances that they cannot use the laboratory because the college students use them for their experiments and activities. According to them, the university prioritizes college students as specified in the provided rule or protocol within the memorandum of the University President stating thereof the schedule on the usage of laboratory rooms; college students, high school students, and outside users need to have an approved request. Thus, STEM teachers postpone the experiment or make an alternative activity. Teacher Bart hopes that SHS STEM students will also be prioritized as he firmly believes that laboratories could provide the best teaching and learning experiences for the teachers and learners by engaging in the hands-on activities conducted in these laboratories.

Based on the collected information, the researcher noted all the challenges since the SHS implementation has begun, such as reports on lack of learning and teaching resources, laboratory equipment and materials, and even shortages of laboratories and classrooms. These issues are not yet resolved despite the claim of DepEd that there is enough budget every year to support the needs of schools (Tupas & Matsuura, 2019).



5. Discipline Integration

Figure 29 exemplifies that even though teachers and administrators think that the STEM curriculum is congested, it lacks some disciplines to be integrated which are important for the completeness of the curriculum. The interviewed participants thought that character education subjects, arts, and other science-related courses are missing in the present curriculum.

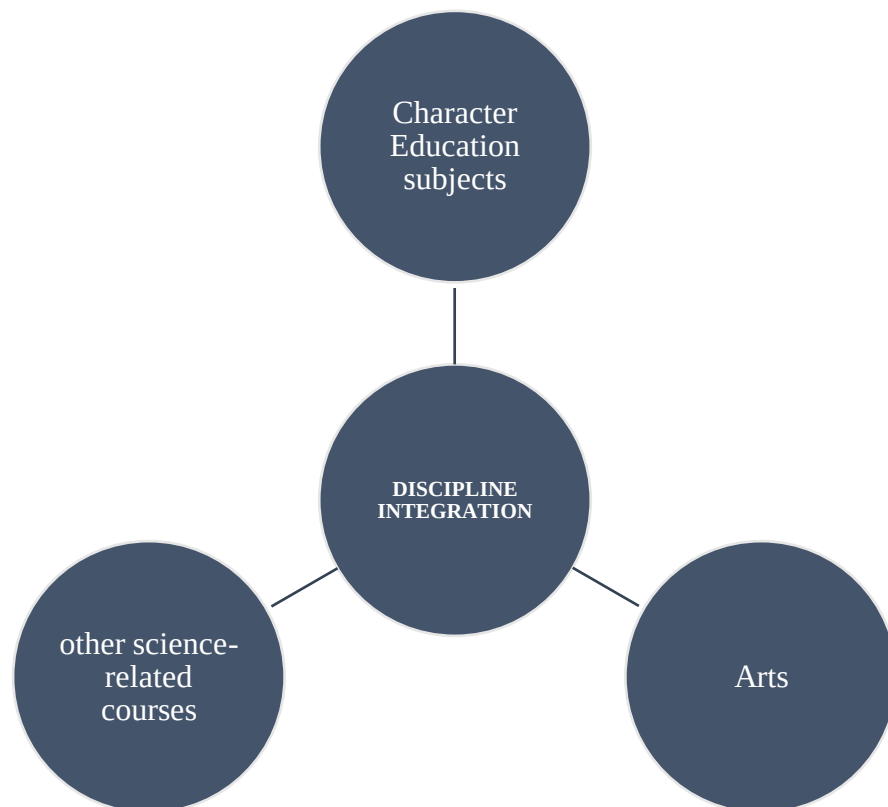


Figure 29. *The subjects that still needed to be integrated as perceived by the participants*



Philippine Normal University National Center for Teacher Education

Character Education Subjects

PISA describes scientific literacy as “the ability to engage with science-related issues but also includes the importance of being able to apply scientific knowledge in the context of real-life situations” (OECD, 2017, p. 1). It refers to the appraisal and evaluation of knowledge and then utilizing it as people and society. In the field of science and technology, schools frequently overlook reflection and evaluation on the subject. Even though there are many interesting and critical ethical concerns that occur in areas such as chemistry, physics, and biology, values formation can be more developed on the subjects concentrating on it. In line with this, teachers strive to create courses that inspire practical application, critical evaluation, and contemplation of the subject matter in a societal context (Anwar, 2015). Teachers feel that youth nowadays should have a triad of the right attitude, skills, and knowledge more than ever before (Siemens-Stiftung, 2021).

Character Education is also needed in the STEM strand as Admin Spiderwoman said that the students need “*GMRC and Religion Subjects for SHS.*” Teacher Cza supports that students need Character Education subjects since “*there are a lot of values that are needed to possess to become a successful STEM student.*” They believe that school is not only for education but also for building positive behavior. As the students spend much of their time in school, teachers and administrators agree that reinforcement of character and values is vital for the holistic development of the students. Honing their values such as citizenship, respect, being responsible, and other social behaviors accompanied with the learning of STEM subjects may provide benefits on the future upholding of the students.



Philippine Normal University National Center for Teacher Education

The school may serve as the avenue for this by providing character education subjects where students discuss, learn, and enact such positive characters and values.

Other science-related courses

In addition to character education subjects, some teachers and administrators claimed that other science disciplines should be integrated into the curriculum. Teacher DeoGirl hopes for more discussion on microbiology since *“this will be a great help for STEM students who will take Medicine.”* She noticed that microbiology is not included in the Biology 1 and 2 of STEM strand. On the upper hand, Teachers X, Jordz, and Alfred believe that courses on environmental concerns should be integrated. Teacher Alfred strongly supports the integration of environmental laws and ethics in the curriculum. He noted that there are a lot of natural calamities we have experienced and encountered from the past that can be attributed to illegal acts or violations against the environment. This idea is also the premise of Teacher X and Teacher Jordz. Indeed, integration of environmental subjects will address our problems on needed flood, typhoon, and this pandemic. Adding environmental subjects to the curriculum will not only prepare students for disasters brought by nature but also to survive the aftermath.

Arts-integration

Meanwhile, Admins Armier, Rina, and Airam Berns stated that the inclusion of Arts in the STEM Curriculum would make it better. Admin Armier quipped,



Philippine Normal University National Center for Teacher Education

“The allied courses are there but the inclusion of Arts in the curriculum is needed because Arts has been a vital part of the humanities but somehow neglected in the STEM Strand.”

Admin Armier felt that the present STEM curriculum is very technical and mechanical in nature. She added that it is overly focused on content. She feared that the students would turn to robots soon because most of the student’s time is spent in the school where they acquire technical information like a machine. Further, she observed that the length of the time spent in school by the students outweighs the time given to the family and home-based activities. She conveyed that the non-inclusion of arts is detrimental to the holistic well-being of the students. She expressed,

“I really see the logic of incorporating the aesthetics, the humanities side, in the technical quest for knowledge where I categorize science. Because otherwise, we are really going in that direction that everything is becoming technical and I won’t be surprised that we would be living like robots even in the educational system if we will not really touch the heart in terms of our teaching and learning. So, I suppose we have to be more human even in the context of acquiring technical knowledge which we usually get from the sciences.”

Admin Airam Berns also expressed the same sentiments with Admin Armier as she asked, *“Why not include in STEM the subject of Arts so that STEM students can also express creativity in their research work and experimentations?”* This is noted by Teacher Maestro in his classes when he asked his students to promote the products of their practical research like Polvoron infused with duhat extract and perfume with antioxidants from red cabbage. He narrated,



Philippine Normal University National Center for Teacher Education

“I told them to market their product, then sell it to their teachers, classmates, or friends in the school. It is the product of their practical research so I hope that they will get profit from it. However, I noticed that they had a hard time designing, branding, and packaging their product. I even said to them that they should be innovative in creating the product. Unfortunately, they cannot draw a simple one. I wish they have arts so it can complement science in terms of marketing the innovations created by the students.”

Analytical subjects such as STEM have been shown to consider only the left brain of the learners while subjects like Arts developed the right brain of an individual. As argued by Admin Armier, “humanizing” the curriculum seems an important one. In several studies, Arts disciplines such as painting, music, theatre, dance, among many others have been shown to improve students’ learning, attention, and cognition (Posner & Patoine, 2010; Zhbanova, 2017). In their study, DeMoss and Morris (2002) have found out that arts-integrated lessons enhanced the ability of the students to evaluate their learning. Thus, the blending of arts with other subjects improved students’ intrinsic motivation and changed students’ perceptions into positive ones making the classroom a place of learning towards understanding (Duma & Silverstein, 2014).

STEM lacking the arts may hamper the learner’s full potential to develop. This is because arts provide the learners with the liberty to explore the competencies and abilities of STEM subjects. Daugherty (2013) revealed that arts could support innovations through skills, models, analogies, techniques, structures, knowledge, and methods. Thus, integration of Arts in STEM discipline promotes more creativity, interdisciplinarity, authentic learning, and project-centered thinking (Crayton & Svihla, 2015; Dyer, 2019;



Philippine Normal University National Center for Teacher Education

Henriksen, 2014; Kim & Park, 2012; Kuhn, 2015; Rolling Jr, 2016; Yakman, 2010). This is the case in the study of Rosen-O’Leary and Thompson (2019) wherein they conducted a study on the effect of drawing on the long-term retention of science concepts in students. The students in the control group used writing and conventional note-taking in the lesson while students in the experimental group employed drawing for their visual notes. The study revealed that the experimental group significantly retained science content and concepts and that arts integration is effective. Furthermore, the study suggests that “the arts play a significant role in learning and content retention in art and science” (p. 32).

According to Zimmerman (2016), the arts may help people develop the critical, creative, and participatory mindsets that are required in the engagement of science. Divergent thinking, appreciating the intricacy of digital communication, experimenting with new methods of expressing oneself, and seeing the intrinsic beauty of the natural world are all possibilities the arts provide for students. Through collaborative projects in which students are assigned responsibilities that relate to real-world jobs to achieve a shared objective, performance, simulations, and collective intelligence may be introduced through arts (Land, 2013). Teachers might use play to direct experimenting with arts by offering questions. Teachers may also encourage multitasking by including music and movies related to the material or by scaffolding responsibilities and assigning several tasks to encourage time management. Distributed cognition, judgment, negotiation, and transmedia navigation important in STEM education can all be aided by projects that use web research, computer programs, and physical art objects. Through assisted community



Philippine Normal University National Center for Teacher Education

arts, people may experiment with networking, simulation, collective intelligence, and negotiation (Oner et al., 2016). Arts-integrated learning modules can help students grasp topics in STEM subjects as well as literacy in general (Segarra et al., 2018).

However, some teachers and administrators expressed their concern about integrating arts in STEM subjects. Teacher Jordz said, *“I really love to teach mathematics with creativity. I just do not know how to do it.”* The same concern was discussed by Admin Airam Berns when she said,

“STEM subjects infused with arts is a novel approach for teachers. Students will surely enjoy the lessons if arts are incorporated into their learning. But the biggest question will be if our STEM teachers could handle that strategy without appropriate training. We cannot deny the fact that during the college years of teachers, they were not taught to teach science and mathematics with arts.”

This statement is in line with the study of Moon (2020) that STEAM teachers in Korea complained about the lack of arts integration experiences and exposure during their pre-service training. Zimmerman (2016) that science teachers are mostly on doing laboratory-based activities than connections on real-world situations and content knowledge. Further, teachers were allegedly forced to combine STEM subjects with arts, according to many accounts. They were taken aback by the inclusion of the arts to the required STEAM education (English, 2017). Because some science teachers are not creative, and others do not appreciate the integration of arts in STEM disciplines, science teachers have a hurdle in integrating the arts into STEM disciplines (Henriksen, 2017). Carsten Conner and colleagues (2017) highlighted the distinction between science and



Philippine Normal University National Center for Teacher Education

the arts and said that teachers sometimes urge the two areas to be blended in order to match their teaching with STEAM Education. Teachers' trust in STEAM instruction is also harmed due to these occurrences.

6. Administrators' Leadership and Management

In recognition of the present “restructuring initiatives,” the call to reconceptualize instructional Administration, Leadership, and Management is in the process of execution which induces a more appropriate range of practice and subsumes educational leadership as the dominant image of school administration in the 21st century. In 1998-1999, SEAMEO Innotech conducted a series of Educational Leadership Training programs in capacity-building among educational leaders of Southeast Asia. The program is designed to respond to the emerging needs of the education sector at the threshold of the new millennium. It considers the critical transformation in the educational landscape that promotes the extensive and optimized use of technology-based instructional strategies and other innovative approaches that will ensure the progress of the learner’s capability to the fullest and the achievement of quality learning outcomes among educational clients.

There are several challenges that have beset instructional leaders today. The fast-paced changes that have impacted the K to 12 curriculum triggered difficulties like understanding curriculum designs, overcoming heavy administrative functions, inadequate reward and support system, and many others. These are some of the constraints that instructional leaders are most likely to encounter that should be



Philippine Normal University National Center for Teacher Education

addressed. Accordingly, the new roles and responsibilities of administrators as knowledge builders of the learners of tomorrow are highlighted leading to educational reforms and renewed interests in matters of excellent performance resulting from quality supervision or monitoring (Minkos et al., 2017). In fact, the effectiveness and efficiency of schools are linked to the accountability of educational leaders (Kalkan et al., 2020).

The education sector, along with other government instrumentalities and agencies, are tasked to contribute to achieving the national development goals. The goals that are specific to education are defined in Article XIV, Sec. 3 of the 1987 constitution. It provides:

“All educational institutions shall include the study of the Constitution as part of the curriculum. They shall inculcate patriotism and nationalism, foster love of humanity, respect or human rights, appreciation of the role of the national heroes in the historical development of the country, teach the rights and duties of citizenship, strengthen ethical and spiritual values, develop moral character and personal discipline, encourage critical and creative thinking, broaden scientific and technological knowledge and promote vocational efficiency.”

To cater to the challenges and concerns of local conditions, the education at the regional level reflects those of the national level but is modified. Reforms in education including national and international funded programs gave stimulus to the implementation of plans and projects.

Sound Administration

Educational administrators flourish in an environment of learning organizations where people’s creativity, critical thinking, and collective aspirations are nurtured and



Philippine Normal University National Center for Teacher Education

where a global learning avenue is built to see and adore the holistic framework of boundless learning. Educational leaders are stewards, designers, and teachers.

Educational administration theories have been reviewed and have given rise to the significance of visioning institutions. In a broad term, vision is meant as: “A mental image of a possible and desirable future state of the organization . . . as vague as a dream or as precise as the goal or mission statement . . . a view of a realistic, credible, attractive future for the organization, a condition that is better in some important ways than what now exists” (Makumbe, 2016). Theories of leadership have provided only a small part of the total picture. It is important for leaders to give attention to two dimensions: the accomplishment of the task at hand and establishing good relationships with and among members of staff. The teacher as an instructional leader is about fostering learning for everyone to develop systematic understandings (Ch, Ahmad, & Batool, 2018). They are committed and guided by the principles of ‘what should be done?’ then it will be internalized as the philosophy of the school.

Administration involves supervision and is concerned with the correctness and effective implementation of agency policies and procedures. It implicates the controlling role and responsibility to ensure that the supervisees work best in their ability. Also, according to Mette (2019), educational supervision recognizes the main issue of a teacher as ignorance regarding skills, attitude, and knowledge necessary to do the job. The supervisor has to dismiss ignorance and elevate the supervisee’s capabilities. Another remedy for teachers’ problems may be solved through supportive supervision because such considers worker morale and job satisfaction. The supervisor seeks to prevent



Philippine Normal University National Center for Teacher Education

potentially stressful situations, reduces stress, and helps the worker to adjust to stress (Wanzare, 2011).

From the data collected in this study, the participants have laid down their foci of supervision and they are as follow: (a) To build a constant space for supervisees 'reflection on the 'what' and 'how' to teach; (b) To develop cognitive and psychomotor faculties relevant to career growth; (c) To provide an organized feedback mechanism relevant to both teacher's and student's success; (d) To accept and respect the new perspective of another; (e) To help co-worker facing difficulties in carrying out the job and alone; (f) To establish a safe space for psychological and physiological expression on struggles with work, restoration of balance, constructive change, the exercise of rights and reformation of professional motivation; (g) To strategize better ways to utilize the available professional resources fully; (h) To be actively ready for any kind of administrative issues; and (i) To guarantee that the work has been done beyond the minimum standard.

The above-cited facts can be connected to these established responses by the participants:

"Ah first we will provide if they need mentoring or coaching in teaching, then on the part of the admin, of course, we continue to improve facilities, purchasing of the equipment needed for instructions. For as long as the funds are available and allowed under MOOE so if there are no funds available, we will outsource if necessary. We do partnerships with different institutions if necessary, for instructions. So that is how we teach teachers and we have faculty and staff organizations that help in addressing the social concerns of teachers. Well, financially, we have a teacher's coop to support. During the pandemic, we have an alternative work arrangement. So, all of that and other forms of support, we give to



Philippine Normal University National Center for Teacher Education

our teachers. Most importantly, we are open to listening to any needs of teachers and then we have hands ready to act and then respond to the best of our ability.” -**Admin Jam**

She added,

“Sometimes our learners, they’re also given the opportunity to come up with their own learning activity procedure. There are times when we do not dictate to them in toto everything they need to do. Just give them a scenario then let them devise, how they plan or how they will solve the problem, how they will conduct the activity in their own strategy so one way that we can develop critical thinking. Well, to help my teachers in doing so, I give them the options to have their class or deliver their lessons in a non-conventional way if they request to do a laboratory tour on campus, as long as, the principal will allow. So, if you need to swap a schedule with another section or another teacher so for example, they can watch a movie related to the lesson or other activities they need to do, just go. So, if you have classes outside the classroom, go. That way teachers are more inclined to think and then prepare more meaningful and more creative learning activities because they know, they are confident that they feel that I support.”

Another mechanism was provided by Admin Armier, she said,

“My support mechanism is in terms of provision of resources. That’s one. Because as the school head, I am the one in charge of the planning requesting and purchasing or procuring the needed supplies and materials. So, since I am really in charge, I made sure that I do have equity in terms of distribution though I must say I really give priority to the science courses because we are in the science high school. But I also see to it that some resources are allocated for the other courses, for the other subjects. Also, ensuring that they are well-rounded people, giving them the opportunity for their mental health enrichment so that they will be healthy mentally, emotionally as well. That is why we are also holding some rest and recreation activities on a regular basis so that we really can give time for our emotional well-being or mental health. I also encourage them to attend seminars and training and conferences though they don’t need much motivation on that aspect because they themselves are driven to capacitate themselves through this training, seminars, and conferences and I am 101 percent in support. So, I always approve their request to attend and even outside the country if they have the opportunity.”



Philippine Normal University National Center for Teacher Education

Bridging the noble concepts of the aforementioned foci, the Code of Professional Ethics for Public School Teachers and Officials reiterates the significance of effective school supervision and administration, to wit:

Article VII: School Officials, Teachers, and Other Personnel

“Section 1. All school officials shall at all times show professional courtesy, helpfulness, and sympathy. towards teachers and other personnel, such practices being standards of effective school supervision, dignified administration, responsible leadership, and enlightened directions.

Section 2. School officials, teachers, and other school personnel shall consider it their cooperative responsibility to formulate policies or introduce important changes in the system at all levels.

Section 3. School officials shall encourage and attend the professional growth of all teachers under them such as recommending them for promotion, giving them due recognition for meritorious performance, and allowing them to participate in conferences in training programs.”

To facilitate the direction of this information, it may be stated that aside from the exercise of management and supervision of teachers for leadership purposes, there are also major tasks for a school leader, such as creating school climate, a strategic scheme used in the attainment of goal and implementation of the defined standards.

Expertise in the hierarchy of instruction is one of the qualities of an instructional leader. The versatility in the performance of duty should be exhibited according to the needs of the circumstances. There are many roles to be played. A leader can be like a ‘chef’ who knows the essential ingredients to make a hearty and nutritious meal that fills in the hungry mind, body, and soul. Sometimes, a leader can be like an automotive mechanic responsible for maintaining all vehicles of learning by giving proper care, performing diagnostics on vehicle mechanical breakdowns and incidence for a safe and



Philippine Normal University National Center for Teacher Education

reliable journey of giving quality education for all. Instructional leadership relies on collaborative planning with teachers, parents, internal and external stakeholders which targets the two domains: curriculum management and staff professional development (Park & Ham, 2016). The interactive functions and concerns of instructional leadership are assigning, supervising, and evaluating. Hence, they are expected to possess the competence to observe teachers, offer advice as needed, listen to the problems encountered, and evaluate teacher performance in formative and summative types.

This practice is demonstrated in a case, one participant, Admin Chard, said,

“Classroom management, this is one of the things to look for when having classroom observation. We monitor class observation, announced and unannounced. The important thing is that when it is announced, the set-up always seems very good, it looks very nice, perfect but you can see the reality when the visit is unannounced, the surprised one. Even if the administrator only peeks for a few minutes, you can already see how the teacher really handles his/her class. Then those should not end up in-class observation, there should have a conference after observation so that the teacher can reflect after what was seen, what I saw in his/her class. So, what I observed, he/she can explain his/her side, he/she can also reflect on how to improve the class”.

Admin Berns raised a different scheme of observation and supervision with the aid of technology, she said:

“As observed, I conduct surprised visits to teachers’ classes anytime, any day. I also observe teachers monthly in their classrooms particularly on the way they handle or teach their learners. Literally, teachers are directly observed through the CCTV.”



Philippine Normal University National Center for Teacher Education

Admin Rina stated one of a kind observation as this would be ended with a constructive goal:

“In our observation, we use class observation tool (COT). In this tool, they will be graded. But after the observation, we are using the appreciative inquiry approach by asking, “What do you think happened,” “What can be done better.” Like that, I direct them.”

Another system is being practiced by Admin Armier, she said,

“Once in a while yes though that once in a while is regular on my part. Regular because I see to it that they have a record of observation for the four quarters of the year at least because we have the ISO evaluation, monitoring, and survey where we really have to abide by the procedures being documented and in the ISO documentation, the head is supposed to ensure the regularity of the expected routine and that one including the teaching of the teachers on a regular basis.”

Her goal is to upkeep the standards to promote the academic achievement of the learners.

Effective Management

The success of school managers depends on their adaptability to change; hence, they are the leaders and managers of change (Hadebe, 2013). They are open and continuous and inclusive to new perspectives relevant to the ever-changing demands of society. This is proven from the experience of Admin Shalom:

“Well, how do I manage my teachers? For us, we take any endeavor as a learning opportunity. Every activity at school I look at, we look at as an opportunity for me and my co-teachers to learn. We usually ask, what went right and what went wrong? And every time that is good so it is continued, with the good of course from there we learn and then the



Philippine Normal University National Center for Teacher Education

unsuccessful activities should not be repeated. That's how I deal with my co-teachers so from the SHS department. Whatever the feedback, it is always forwarded to higher authority so there's always two-way communication. Our school is obedient in implementing whatever guidelines or mandates of higher authorities. We are obedient, but I am open to their feedback and suggestions every time I relay orders or instructions to my teachers. Honestly, there are instances that are sometimes unrealistic or applicable to the policies laid down by DepEd, sometimes very idealistic, there are times like that. Sometimes there are authorities who have not yet experienced what is really happening below, so sometimes what we are asked to do is different or their mandates are different. So, when I relay orders and instructions to my co-teachers, we usually discuss and then we agree on how to get things done considering the real context and situation on the field. Of course, without deviating from the given DepEd orders, we think of what's best for our learners."

It is also interesting to learn one management technique shared by Admin Armier, she said:

"Actually, the teachers in the STEM Strand don't need much management technique because they manage themselves. I am more on support especially with the resources maybe because they cannot deliver the lesson well without the resources so I make sure that the resources are available at least to help them facilitate learning but in terms of the delivery, they manage the delivery themselves."

This type of democratic management fosters cultivating professional openness and honesty on the needs of work to understand the inevitable shortage towards teaching-learning. This management is needed the most when teachers have diverse backgrounds (Kilicoglu, 2018). Diversity in the educational sphere creates complexities. Part of the role of educational leaders is to establish a harmonious relationship with a unified education goal among all the school community members. The educational leaders should maximize their engagement to guarantee the holistic development of learners in



Philippine Normal University National Center for Teacher Education

the school. The management of the instructional leaders is so trusted with moral and transformational power over the organization (Thornton, 2014).

The interview also revealed that administrators' management encompasses school resources and systems, staff performance, and sustainable school programs and projects.

Transformative Leadership

Figure 30 shows the consolidated essential roles being played by the participant-administrator as reflected from the interview conducted by the researcher with them. Their acts have invited diverse theories and practices that respond to What, How, and Why the present curriculum works for the learners and how these factors will respond to the ever-changing trends in education and community. This part points out a transitional framework from instructional leadership to transformational leadership, which would enhance transformative education.

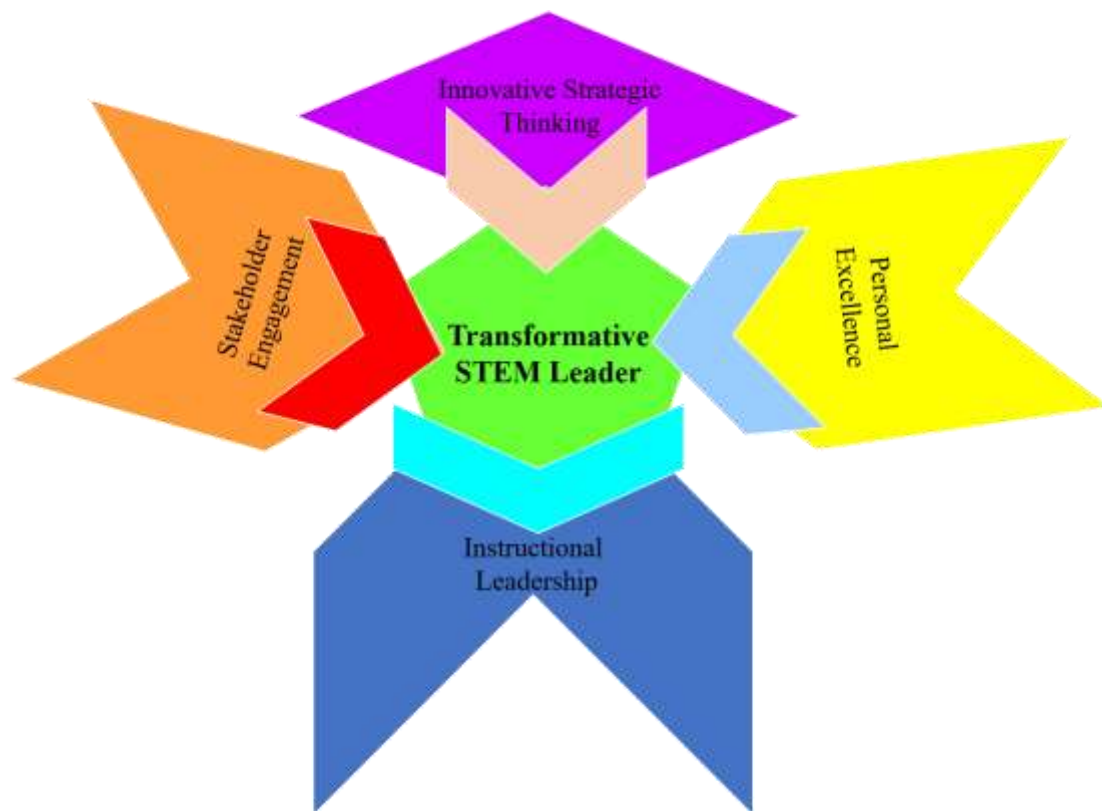


Figure 30. *The illustration of how participants see a transformative STEM leader*

The researcher deduced four sub themes from their responses on how they provide sound leadership for their school, leading them to become a transformative STEM leader (Figure 31). From their experiences, interviewed administrators provide instructional leadership, strategic thinking innovation, stakeholder engagement, and personal excellence. Their instructional leadership includes leading curriculum and development implementation, establishing a learner-centered atmosphere, monitoring and assessing teachers undertaking, and achieving the desired learning objectives. On their personal side, excellence is maintained through managing personal effectiveness, acting on educational challenges and possibilities, observing integrity at work, and participating



Philippine Normal University National Center for Teacher Education

in professional development programs. In addition, their stakeholder engagement is also considered important. STEM Administrators do this by establishing educational networks, practicing the culture of shared responsibility, strengthening educational connections, and building partnerships with stakeholders. Lastly, STEM Administrators' strategic thinking innovation includes strategizing the school's goal direction, providing well-defined decisions, and creating learning innovations.

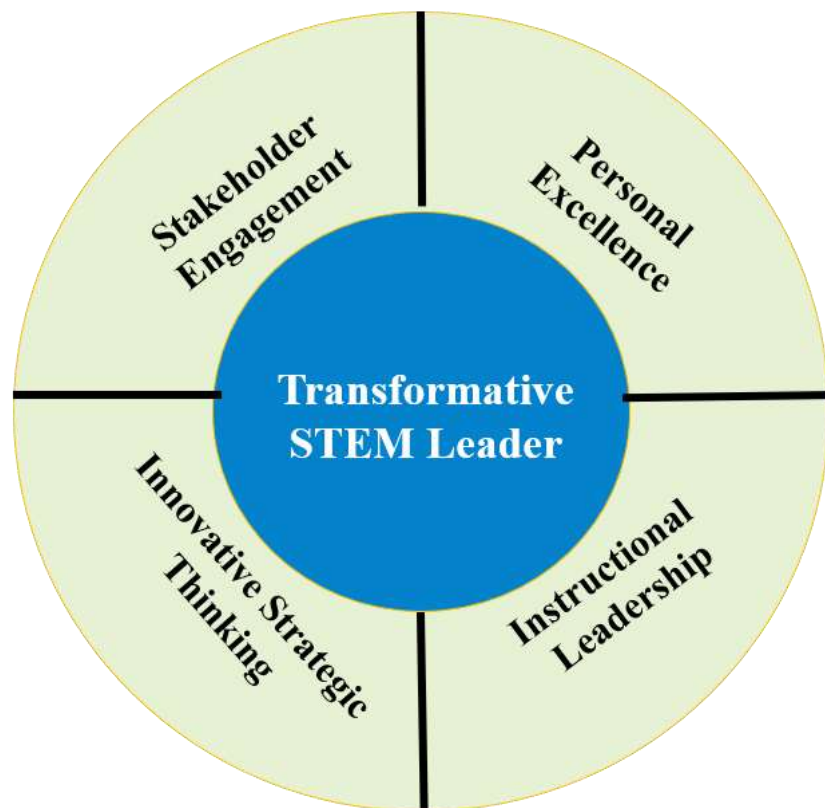


Figure 31. *Model for a Transformative STEM Leader*



Philippine Normal University National Center for Teacher Education

Change of views according to experience is the greatest objective of transformative education (Lange, 2018). Transformational leadership is linked to cooperative learning and issue spotting and resolution. Leaders are expected to move from demanding conformity and compliance to encouraging and supporting innovations and creativity. Leaders are expected to work in a setting that is not definite and certain and they have to continuously know how to survive a systematic change and not just be complacent maintaining status quo (Oreg & Berson, 2019). When teachers and school leaders reflect and begin to question assumptions and have new views, they undergo transformational reflection leading to changes in action. The transformative process requires that educational programs explicitly address critical analytical skills and active search for meaning (Bamber, Lewin, & White, 2017). Meaning is essential to transforming perspectives and institutions' response to accept and adopt changes. Transformative Leadership is a call in the 21st century because it evokes a more appropriate range of practice (Figure 31). As one can infer, the essence of leadership gives a meaningful scheme for the attainment of a goal through redefining the institutions' mission and vision for the people. The nation needs 21st-century leaders who are competent in instructional and technological aspects which are necessary to achieve an excellent academic performance of learners.

7. Students' Skills

The STEM teachers during the interview said that the present STEM curriculum is effective in instilling the necessary skills of students in academic and non-academic



Philippine Normal University National Center for Teacher Education

spheres. As the future STEM workforce of the country, the students are being trained on the skills that they need in the job market through the STEM strand. The teachers and administrators characterize the curriculum as comprehensive for the student's skills yet there is still room for improvement. Also, the STEM strand is described as perfectly fit to equip students with the required 21st-century skills and Future skills in the era of Industry 4.0. Some of the skills honed in the students include problem-solving skills, collaborative skills, and analytical skills.

In the previous theme, the interviewed teachers were characterized as *Communicating Teacher*, *Engaging Teacher*, and *Transforming Teacher* based on their pedagogical characters. With their strategy and technique, it was construed from the interview that their goal is to develop STEM students who are innovative, creative, critical, and reflective individuals.

We [Teachers] must be open to questions during discussions to promote reflective and critical thinking. We have to elaborate their thinking by entertaining their questions. (Teacher Cza)

They are trained individually and in groups. Also, I use the brainstorming process so that they will think actively and creatively and at the same time, critically. Moreover, I told them to use recyclables and indigenous materials in their projects in biology specifically in plant and animal cells, in such a way that their innovativeness will emanate. Further, through individuals such as reporting and by giving them research study about genetic engineering. So, by using various teaching activities in STEM, I aimed that they could show and improve their skills. (Teacher Maestro)

Giving activities and experiments will help the reflective and critical thinking of the students. In these learning tasks, the students will be the ones who will explore and answer to any developmental pursuit by



allowing to be free to make decisions based on encouraged learner's self-initiative goals and approaches. (Teacher Michael)

They believe that by having innovative, creative, critical, and reflective skills, the STEM students will become holistically developed, thereby producing competent and productive citizens (Figure 32).

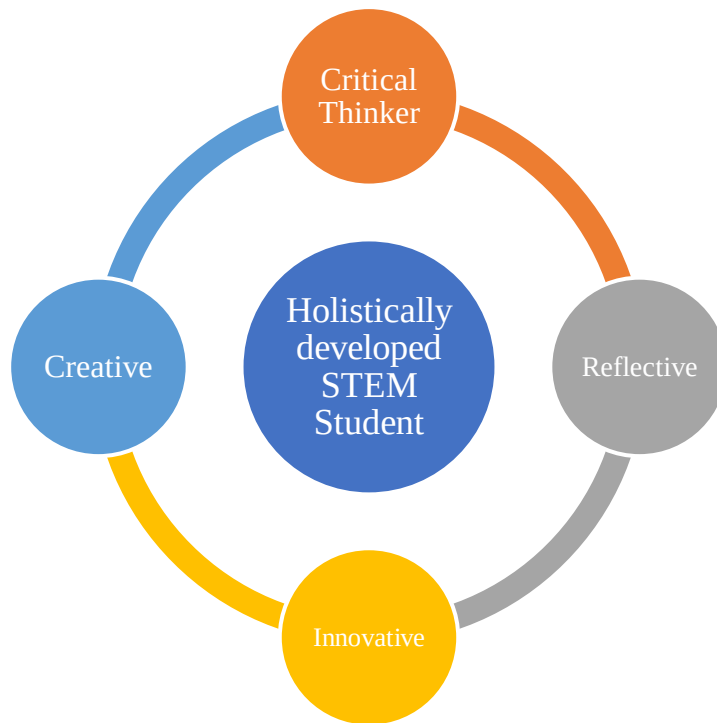


Figure 32. *The skills of the learners that are developed and improved by STEM Teachers to produce holistically developed students.*

As emphasized by the participants, the mentioned skills must be altogether learned, attained, and practiced by the students in the senior high school to show their full potential. This reason explains the interconnections of the four skills in the figure.



Philippine Normal University National Center for Teacher Education

Students are taught to be accountable for themselves. Through the curriculum, they are expected to be provided with concrete structures which will facilitate healthy assessment of oneself in terms of one's learning progress. Ultimately, the greatest gift teachers can give to their students is to realize the value of learning and be responsible and accountable for it.

Innovative Individual

The interviewed participants believe that a person is innovative if they can adapt to changes and use contemporary methods and technologies necessary in learning; to achieve the apt and suitable ways to integrate materials into practical wisdom or those methods that simplify the information to be useful and the ability to understand how to utilize it. Ultimate success, in reality, is always anchored on innovation and making breakthroughs no one else has achieved. The people principally involved beyond the norm are called innovators. They are braced to step away from the tried-and-true methods to shape their own advanced way.

Innovative individuals can enlighten the whole industry with their ideas. Because of this, their existence influences generations to come (Semenyuk et al., 2019). To make this possible, a learner should be cultivated through the STEM curriculum to develop a certain habit that supports and heightens creativity.

Critical Thinker

As described by the interviewed participants, a critical thinker is a person who has an understanding of the embedded information through the minutest detail in a



Philippine Normal University National Center for Teacher Education

heightened state of thinking. Critical thinking enables people to research and evaluate large amounts of information from a vast source to arrive at a reliable and meaningful quest for knowledge (Nappi, 2017).

The sense of freedom for learning free from all unnecessary discrimination or restraint is the foundation of critical thinking (Birgili, 2015). The learner is welcome to practice cognition of things which could be helpful to determine inner and physical strengths, deficiencies, and choices of learning which are reliable in the instructional assessment. Developing critical thinking among students can help them sense the concrete positive results of learning by recognizing their decision, thereby increasing their self-worth (Sarigoz, 2012).

Teacher Jed emphasized the need for critical thinking as he said,

"I hope STEM students will become critical thinkers. Critical thinkers are essential for investigating and comprehending the world we live in because they think rationally and clearly and create logical connections between concepts."

STEM teachers hope to create critical thinkers who continuously seek to improve their knowledge and participate in autonomous self-learning. They want students who are rational, analytical thinkers and apply introspection in their analysis.

Creative person

Participants described a creative person as an individual with an ability to direct the intellect to come up with solutions to challenges and develop a more evolved answer



Philippine Normal University National Center for Teacher Education

in connection with the existing status quo into a novel work that is improved through an individual's thought process.

Creativity is a gift and natural to everyone. The teacher has to propel students to bring out their unique side of learning. Today, the rapid technological change in our society calls for more creative people who can greatly influence people's way of life. Science as an art has to be exciting for all. It requires students' more cognitive processes or thinking beyond normal to logically solve some of the things believed to be mysterious.

STEM students are groomed to be the innovators, discoverers, and builders of the future world that is why their creativity must be maximized and nurtured while they are at school. Participants want their students to think outside the box naturally. They want their students to become creative learners who are inherently interested and have a desire to understand how their environment works. They want engaged students who love studying when the material is relevant to them.

Reflective Learner

The participants shared that through reflective pedagogies, they will be able to develop reflective learners who have the ability to merge fundamentals and complex materials into real and practical intelligence in such a way that they can navigate the information and can easily place it in a way that is accessible when the situation demands.



Philippine Normal University National Center for Teacher Education

In attaining this kind of learner, Choy and Oo (2012) recommend that educators consider four factors to wit: learner's motivation, attitudes, and ideas; changes in learner's skills needed for different components of studying; obstacles in learning; and the gaps in learner's knowledge and skills and how these should be addressed and resolved. In responding to the foregoing facts, the teacher should respond to prepare and execute the teaching-learning process with which the reflective learners have to be engaged. An effective way to practice the art of reflection in class is by following a functional model to invite the critical, analytical, and creative mind to ponder the concept of success and failure from the entire learning experience. Interview corpus revealed that the most common learning activities in STEM subjects are collaborative in nature which makes it difficult for the teachers to make individualized monitoring of student's progress. To solve this, the teacher's initiation on giving a student's reflection phase after the lessons will help because it will stand as a gauge for each student to engage in an in-depth learning internalization towards life-long skills and knowledge (Ghanizadeh, 2017).

8. Assessment Practices

Interviewed teachers shared that *Assessment* is their prime instrument in effectively determining the progress of STEM students' learning, performance, and skills. This is in consonance with the definition of Department of Education of assessment as "a process that is used to keep track of learners' progress in relation to learning standards and in the development of 21st-century skills; to promote self-reflection and personal



Philippine Normal University National Center for Teacher Education

accountability among students about their own learning; and to provide bases for the profiling of student performance on the learning competencies and standards of the curriculum” (Department Order No. 8, s. 2015). As *communicating, engaging, and transforming teachers*, STEM teachers implement such DepEd assessment strategies. Even Higher Education Institutions (public and private) and private secondary school teachers follow the prescribed DepEd assessment tools and grading system. Teacher Joe, a private HEI teacher, shared,

“Even though we are in an HEI, we still follow the DepEd guidelines in the assessment. Even in giving grades, we follow the template and transmutation of the DepEd Grading System.”

Primarily, the grading system in Senior High School is divided into three: Performance Tasks (PT), Written Works (WW), and Quarterly Assessment (QA). Written works include long quizzes, long/chapter tests, written reports, and essays. For the performance task, written outputs, research projects, multimedia presentations, oral works, group presentations, and skill demonstrations are recommended. Quarterly Assessment may be based on a performance-based assessment or objective tests or a combination of the two. The PT, WW, and QA encompass the assessment strategy of the teacher for the whole quarter or school year.

All strands have the same criteria for assessment but have different percentages. For the academic track where the STEM strand belongs, core subjects, such as Media and Information Literacy, Statistics and Probability, and Understanding Culture, Society, and Politics, among others, are graded as 25% WW, 50% PT, and 25% QA. For specialized



Philippine Normal University National Center for Teacher Education

subjects that include General Biology, General Chemistry, General Physics, and Calculus are graded as 25% WW, 45% PT, and 30% QA. However, the said criteria and percentages are intended only for summative assessment. Such is stipulated in Department Order No. 8 s. 2015 titled *“Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program.”*

Additionally, interviewed teachers claimed that they are using formative assessment. They implement assessment for learning, the assessment as learning, and the assessment of learning principles in their classroom. Through formative assessment, the teachers track the students’ strengths and progress while evaluating the needs and weaknesses of students’ performance. STEM teachers stated that they most commonly do games, discussions, open-ended questions, K-W-L activities, practice exercises, drills, and problem sets as formative assessments for their class; it is important to note that these go well with the Mathematics subject.

According to them, they promote reflective questions in multiple-choice questions. However, they still use Lower Order Thinking Skills (LOTS) such as remembering and understanding in their quizzes and examinations. The teachers also shared that in performance tasks, they apply Higher Order Thinking Skills (HOTS) aligned with their objectives to produce innovative, creative, critical, and reflective STEM Strand graduates (see Student skills). They use authentic assessments like role-playing, simulations, and portfolio to promote innovation and creativity among STEM students. Role-playing and simulations provide technical know-how on the STEM courses that the students take, as well as when they are part of the STEM workforce.



Philippine Normal University National Center for Teacher Education

STEM teachers asserted that they use authentic assessment more to let the students apply the information they obtained in real-life scenarios. The teachers hope that the learning gained by the students can be used in different settings, situations, and contexts.

Teachers in STEM commonly use the aforementioned assessment tools and strategies. They usually aligned their assessment based on DepEd's learning competencies, performance standards, and content standards. With these assessment practices, teachers make better decisions in instructional strategies that they implement to be congruent with the abilities of the students. Through these practices, teachers serve as enablers of students in identifying specific areas where the students could improve, making them responsible for their own growth and learning.

In addition, collaboration with their colleagues was practiced by interviewed teachers when they were developing summative assessments. The teachers collaborate by contributing test items and through evaluation of the difficulty of the exam. The STEM administrator also helped by checking the exam content to see if it followed the standards. The administrators give suggestions for the improvement of the examinations. In DepEd, a division-wide exam is encouraged so collaboration among the teachers is practiced. The collaboration allowed the teachers to work with various faculty members to implement new practices and help troubleshoot areas of concern.

However, most of the interviewed teachers agreed that they patterned most of their assessment to that of the exit assessment of DepEd so that the students would be acclimatized to the test. The exit assessment administered to the Grades 6, 10, and 12 students aims to determine if the learners attained the desired learning outcomes for the



Philippine Normal University National Center for Teacher Education

level and to monitor the basic education system of the country in general. The exit assessments are vital components of the assessment framework of the Philippine Basic Education system as provided in DepEd Order No. 55 s. 2016 titled *“Policy Guidelines on the National Assessment of Student Learning for the K to 12 Basic Education Program.”* Teachers shared that most of the time, they think of the national exit assessment as a guide to their assessment since they want their school to have an outstanding performance. Yet, the teachers also recognized that thinking of this alignment hinders their creativity on assessment. One teacher said,

“I think I was prevented from having a different form of assessment since I should always put multiple-choice questions in preparation for the Grade 12 exit assessment.”

Another teacher shared that there are times when he wants to have a new type of assessment, but he will not pursue that type of assessment since it is time-consuming. Other STEM teachers also expressed difficulty in providing authentic assessment. They pointed out that authentic assessment must be well-structured; otherwise, the results and application can become unpredictable. This unpredictability raises the likelihood of something going wrong and jeopardizes students' ability to demonstrate their abilities (Villarroel et al., 2020). Further, they said that developing and implementing authentic assessment takes time and intensive materials. However, they did note that these obstacles can be overcome with proper preparation and structuring using rubrics. In



Philippine Normal University National Center for Teacher Education

addition, teachers carefully articulated assessment tasks from the start to help students control their course requirements.

Interview corpus revealed that STEM teachers are keener to use traditional assessment than authentic assessment. Their inclination towards traditional assessment may be attributed to their lack of technological competency (see Teacher competencies). They have no means of incorporating a new method or mode of assessment since they lack technological knowledge and skills, thus, they are inclined more to use traditional assessment. They admit that their technological incompetence limits their option in providing authentic assessment. Noteworthy, these teachers expressed their willingness to learn and know the technology to incorporate them in their assessment.

Authentic assessments that require students to think like professionals in the field can be achieved through well-designed summative assessments. In this type of assessment, both the learners and the teacher must devote considerable time. To approach, assess, and solve a problem that may take considerable time to solve, the learner will be expected to think objectively and apply a variety of skills. Meanwhile, the teacher will need to spend more time evaluating and grading the students' work when using a conventional evaluation approach like a multiple-choice test (Gunasekara & Gerts, 2017).

Good assessment practices could improve teachers' instruction and students' learning. The primary role of assessment is to develop the learners to acquire knowledge, attitudes, and skills that they could use for their future (Willis & Klenowski, 2018). In addition, good assessment practices prepare students for “the variety of tasks and



Philippine Normal University National Center for Teacher Education

situations which they will confront in the rapidly changing and complex environment they will experience beyond graduation” (Grion, Serbati, & Nichol, 2018, p. 3).

9. Safe Learning Space

Educational environment refers to the overall status of the human setting, which impacts learners' motivation, whether human or non-human. Human factors revolve among the circles of the learners including their parents, guardians, peers, and teachers together with the entire school community while non-human factors include schools' available facilities, the learning opportunities, and the school's atmosphere (Schonrock-Adema et al., 2012).

Sourced from the researcher's correspondence with the STEM teachers and administrators, they provided a glimpse of their experiences at school on the importance of safe learning spaces and some concrete steps that one can take to create this. Physical spaces are central to creating a new model for learning. Participant Admin Will said,

“Learning environment is an important aspect in teaching. I let my students feel that they are all rivals. Rivalry lets my students be excited and challenge every day. It gives them a sense of satisfaction. When it comes to safety oh well, we just need to follow the house rules inside the classroom. And when I say we, even the teachers need to follow it to maintain a none double standard environment.”

Students' safety is the cardinal consideration in the learning environment. Students must feel safe to engage fully in their development inside the school. This provision is highlighted in the second domain of Philippine Professional Standards for



Philippine Normal University National Center for Teacher Education

Teachers (PPST) titled *Learning Environment*. In this domain, the role of the teacher to “provide learning environments that are safe, secure, fair and supportive in order to promote learner responsibility and achievement” is emphasized (DepEd Order No. 42 s. 2017). Teachers should construct a learning-focused environment in which they can effectively control learner behavior in both the virtual and physical spaces.

Admin Armier shared her profound happiness about the school environment she is into,

“We are really proud of the learning environment that we have in school, we are at the seat of a university. We are inside of a big university and we are in a very strategic place, in a strategic location because we are near the administration building. We have a recreation area nearby. We are also close to the exit and entrance of the University because we are near the main gate where the security guards are housed. One or two security guards are deployed to protect the vicinity of the school and so I believe in terms of security, at least in Physical security we ensured that. Emotional security, I guess, our teachers are emotionally healthy enough, all of them. All of us are emotionally healthy and stable enough to deliver learning in an emotionally stable way. So, I can say we are trying our best to ensure the safety and security of the general well-being of the students. Psychological, because we are inside the university and we have the Office of Students Affairs where we have the available guidance counselors who attend to the needs of the students’ mental health. I think that is being addressed.”

From the participants’ responses, a call for collaborative work among teachers and administrators must be conducted to encourage the developed relationship through positive communication to work well and provide operation schemes to make their students become interactive and committed to every academic and non-academic undertaking. Further, a student’s sense of identity and self-confidence can be enhanced in



Philippine Normal University National Center for Teacher Education

a safe learning atmosphere. As recognized in PPST, a safe learning environment encompasses a secure educational environment and other factors such as diversity and inclusivity, protection from violence both within and outside the school, and appropriate pedagogy and curriculum. Schools aim to provide students with quality education, which cannot happen without establishing a safe learning space (Prashanti & Ramnarayan, 2020).

In line with this objective, the researcher has noted responses that illustrate the kind of responsibility the selected school administrators and teachers exercised to maintain the safe learning space: First, Admin Airam Berns stated that *“before the school year begins, I ensure that everything is ready. A complete line-up of faculty, maintenance, and staff, well-lighted and ventilated classrooms, complete facilities in the laboratories, clinic, comfort rooms, including sports equipment are prepared.”* Second, Teacher Maestro shared, *“just simply providing an appropriate learning for students and at the same time by using the right resources.”* Third, Teacher Jordz explained, *“Good ventilation and clean surroundings are my considerations to promote and maintain a safe learning environment. It is difficult to teach when it is too hot in the classroom. Because without aircon, children can't solve because it's too hot. It affects them therefore it is important as well.”*

Teachers' affective traits such as caring, understanding, genuine respect, enthusiasm, and professionalism are important elements to build a healthy, safe space for learning (Colton, Langer, & Goff, 2015). With this, the researcher appreciates the practice of Teacher Cza as she said,



Philippine Normal University National Center for Teacher Education

"I make sure that I have a good relationship with the students. Clear communication was also established in the classroom. Trust was also promoted at all times to ensure harmonious relationship with the students."

Teachers should be trained on how to create the most effective learning environments for the diverse identity of their students. Students often discriminate against one another due to gender, ethnicity, disability, and other factors. For these cases, teachers are vital to resolve and communicate these sensitive issues among students. Admin Spiderwoman shared an experience, she said: *"I give them motivation and room for their mistakes same with improvement. And I'll make sure that there's no room for competition in my class just cooperation sharing of ideas or their own learnings."* The students' sense of belongingness to a learning community and parents' supportive behavior definitely creates a learning environment that is facilitative of learning. Teacher Joe said, *"We have PTA donations/solicitations for the lacking materials in the room such as TV and electric fan. We do classroom structuring per quarter such as changing seating arrangement."* The contrast of these produces a counterproductive learning environment.

Authorities need to better raise awareness about the challenges that schools face with hazardous school buildings so that students' learning environment is safe, effective, and inclusive. There is an instance that called the researcher's attention when a STEM administrator revealed that her school allows using the building even though there are possible hazards. This is in the case of Admin Rina (AM) in her school, where a newly



Philippine Normal University National Center for Teacher Education

constructed building is defective but they are still using it. This can be read clearly in this interview transcript.

Researcher (R): *In terms of the learning environment, how do you ensure and promote the best learning environment in your school?*

Admin Rina (AR): *We have laboratories but these are not functional.*

R: *Does it mean you are conducting laboratories outside?*

AR: *Whatever is available and it is not safe. Last year, a building was constructed but not yet turned over because the previous principal did not sign the contract due to cracks and other concerns. However, due to limited classrooms, we are using the building.*

R: *You allow them to use the building?*

AR: *I let them use it since there is no choice. We just put signages.*

R: *How about if someone meets an accident?*

AR: *It will just be reported.*

Her perspective may be interpreted as having taken the lead to inform the school's environmental risks. However, even though there is a risk in using the building, she took the initiative to put signages for safety measures.

The interviewed teachers also practiced a safe learning environment through their classroom management. The classroom climate is the by-product of the social interactions between and among teachers and students. Teacher Flor pointed this out as she said, *"You have to establish your authority but at the same time you have to maintain a two-way process of communication in class."* To elaborate the communication practice in this context, Teacher Alfred provided that he was able to manage his students with



Philippine Normal University National Center for Teacher Education

constant communication, follow-up, and motivation. Constructive feedback, due recognition, and promoting a positive environment make his students participative and cooperative. In this regard, classroom management as a process of creating and maintaining a safe learning space is dependent on the teacher's factor in creating an environment ideal for learning in harmony with the objectives (Djigic & Stojiljkovic, 2011). Therefore, the satisfaction of both parties, the teachers and students, can be achieved by the climate created through their interaction and constructive intervention.

To link these mentioned undertakings, the researcher gathered some highlights from the participants to show substantial internalization in the field:

1. Defining and practicing classroom rules and procedures:

"At the start of my classroom meeting, I set rules during and after class activities in which everybody knows what to do, how to do it, and what not to do. I see to it that everybody in the class feels comfortable during the discussion, they have to listen and ask questions if necessary for confirmation or clarification. I see to it that there is time for serious work and time for happy moments by their learning environment is very evident in the classroom. I call their attention." - **Teacher DeoGirl**

"From the start of the semester, I establish rules and regulations in the classroom that will be implemented." - **Admin Sensei**

"Rules were documented to ensure that all students understood the rules. Good behavior was also rewarded; however, punishment of the class was avoided." - **Teacher Cza**

"Effective classroom management requires 1. Patience 2. Good timing 3. Boundaries 4. Instinct. It is not easy to manage multi-intelligence with a number of more than 45 students. Basically, I give my students what I call house rules when we all follow it inside the classroom" - **Admin Will**



Philippine Normal University National Center for Teacher Education

2. Arranging the physical space to encourage student's responsibility for learning

"Proper seating arrangement and silence should be observed during the class discussion but they are free to ask questions. It is not bad to ask. So, because the question somehow, develops critical thinking that can be acquired by learners. SHS students are silent. They are already mature. I can infuse in my discussion everything because they are quiet." - **Teacher Jordz**

"I have index cards with their names on it, and their seats are arranged in alphabetical order." - **Teacher Joe**

3. Inculcating discipline among students

"Same with pedagogy. Because I have never had such an experience, just recently. Three years is nowhere enough for a real classroom setting for me Sir. Noise reduction is possible. STEM Students are known for their behavior that is focused on the topic when they play, they will have a hard time." - **Teacher Michael**

Diversity of students makes the environment complex and this should need a strong classroom management skill which involves: a wide array of knowledge in handling any unforeseeable or foreseeable events in the classroom; ability to simplify and summarize numerous information to come up with an ideal solution; and action at the most convenient time to give an expanded discussion (Ahmed, Ambreen, & Hussain, 2018). These classroom management skills are applied from the professional routine of some interviewed participants. They have provided the following details:

*"Classroom management, this is one of the things to look for when having **classroom observation**. We **monitor class observation**, announced and unannounced. The important thing is that when it is announced, the set-up always seems very good, it looks very nice, perfect but you can see the*



Philippine Normal University National Center for Teacher Education

reality when the visit is unannounced the surprised one. Even if the teacher only peeks for a few minutes, you can already see **how the teacher really handles his class**. Then those should not end up in class observation, there should have a **conference after observation** so that the teacher can reflect after what was seen, what I saw in his class. So what I observed he **could explain his side, he can also reflect on how to improve the class**. - Admin Chard

What we can get from Admin Chard is that he is conducting classroom observation and monitoring based on real-time scenarios. There is also much professional support coming from the administrator and shall be given to the classroom teacher if there are troublesome or conflicting areas to be handled immediately. In this way, a good conference and reflection can be achieved to bring out what is best for the students and teacher when they are inside the learning venue. To give a more concrete view on the experience of Admin Shalom, he shared,

“Well, the pure lecture method of teaching is strongly discouraged, we really do not allow that. We are realistic, when we say actual class, the lecture will not be lost because that is exactly what is happening inside the class, right? But we make sure that there will always be other activities that maximize learners for participation. So, the differentiated instruction and variation of activities, we give importance to that every time we check the lesson plan or learning log of teachers. There we can see that they are doing something in class that is engaging and then there we see the collaborative learning. So when well-planned, you will most likely picture there how he or she will execute in his class.”

It can be inferred from his account that he has taken ideas from effective monitoring and observation. Seeing what is really happening can guide an instructional leader to come up with what to take or what not to take in the teaching-learning process as an element of classroom management and the same way as the creation of classroom



Philippine Normal University National Center for Teacher Education

climate whether we are into the qualification expected for a global classroom ready for the 21st century. The researcher noted another quoted statement from Admin Armier, she said, *"I physically monitor the classes."* Physical supervision in classes can give a boost to any teacher which leads to a manageable space for learning. In terms of support, it shall be extended to all to provide training and development for teachers to enhance their classroom management skills. Admin Shalom emphasized this aspect,

"We provide a lot of support to teachers. I'll just enumerate some of the aspects. First is our support for professional growth and development. Every time we have the opportunity, we send teachers for training, seminars and then at school we do our own LAC sessions, Learning Action Cell Sir, then we encourage them to pursue graduate studies. So do I, I need to study as well."

In sum, classroom management is vital for successful teaching focusing on the students' academic recognition. The teacher's encouraging traits in communication promote students' cooperation in the classroom, students' positive behavior on respect, students' appreciation by reason of their initiatives, and motivation to learning (Camp, 2011). In addition, a teacher should utilize his or her own formulated methods and materials to make the whole class actively participate in the learning activities. Well-designed activities and well-focused learning goals will create a positive impact on management with the emphasis on students' disciplined nature during the whole procedure (Korpershoek, 2016).

To synthesize the kind of classroom management being described here, it is proper to state that the teacher is likened to the writer of the settings and conducive



Philippine Normal University National Center for Teacher Education

learning scenarios, which sets the learners' mood as actors and activators exploring personality development. In this way, the classroom becomes a safe learning space venue to hone the students' talent, skills, and knowledge. Best results can be achieved with the support of the administrators who are dedicated in doing their role physically with teachers as they create protocols for classroom management. The teachers' and administrators' undertakings have shown reliability in educational practice.

With all the explanations, Figure 33 shows the safe learning space which is the general consideration in every school, generated from the interviews conducted with the STEM teachers and administrators. Schools considered as the second home should be conducive to all students, teachers, parents, and the community (Ali et al., 2020). It is the venue where the future builders of society are born. A safe learning space is affected by environmental factors, teacher's affective traits, classroom climate, and physical environment. The environmental factors are those human factors seen in the community that influence the students in school. The physical environment deals with the overall structure, equipment, and facilities of the school to determine some considerations, such as level of security, the safety of buildings, controlled and manageable space for students with varied academic and non-academic needs, disciplined space for all for values formation, presence of safety equipment for every building and many more. Meanwhile, a classroom climate that invites learning and the overall development of learners can be achieved through classroom management. Last is the teacher's affective trait, which the researcher considers as the most important among the levels of safe learning space because it deals with the appeal to emotions and the heart of education. Reaching the



affective level of the students can shape their emotional stability towards learning. It promotes human factors in building their intrinsic motivation and the harmonious relationship among the elements of the school community towards one common goal (Karner & Kogler, 2016).

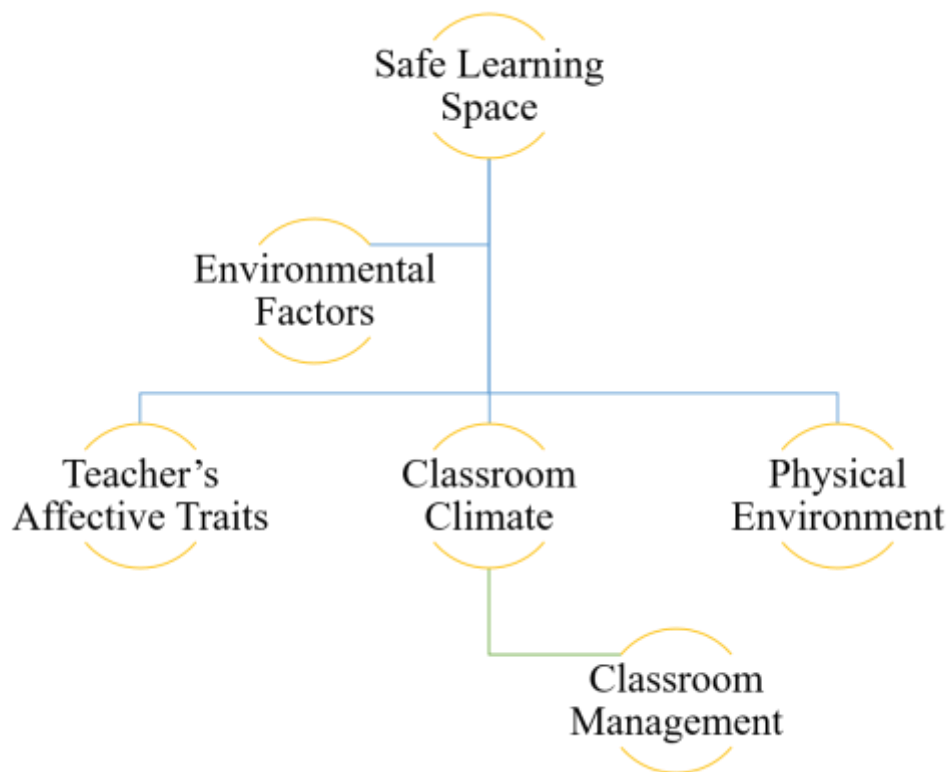


Figure 33. *The totality of safe learning space.*

10. Policy Reorientation and Harmonization

Policies are rules that are proposed to help schools teach learners effectively, equally, and securely according to the administrative standards and the government



agencies to which the schools are partnered and associated (Cobb & Jackson, 2012). The policies are intended to regulate how learners are instructed, how they are educated, and how schools oversee learners and their faculty. Thus, policies help characterize schools' rules, guidelines, systems, and conventions (Ward et al., 2015). These policies are important to help a school run easily and securely and to guarantee that learners get quality instructions. These provisions ensure a productive learning climate not only for students but also for the school personnel.

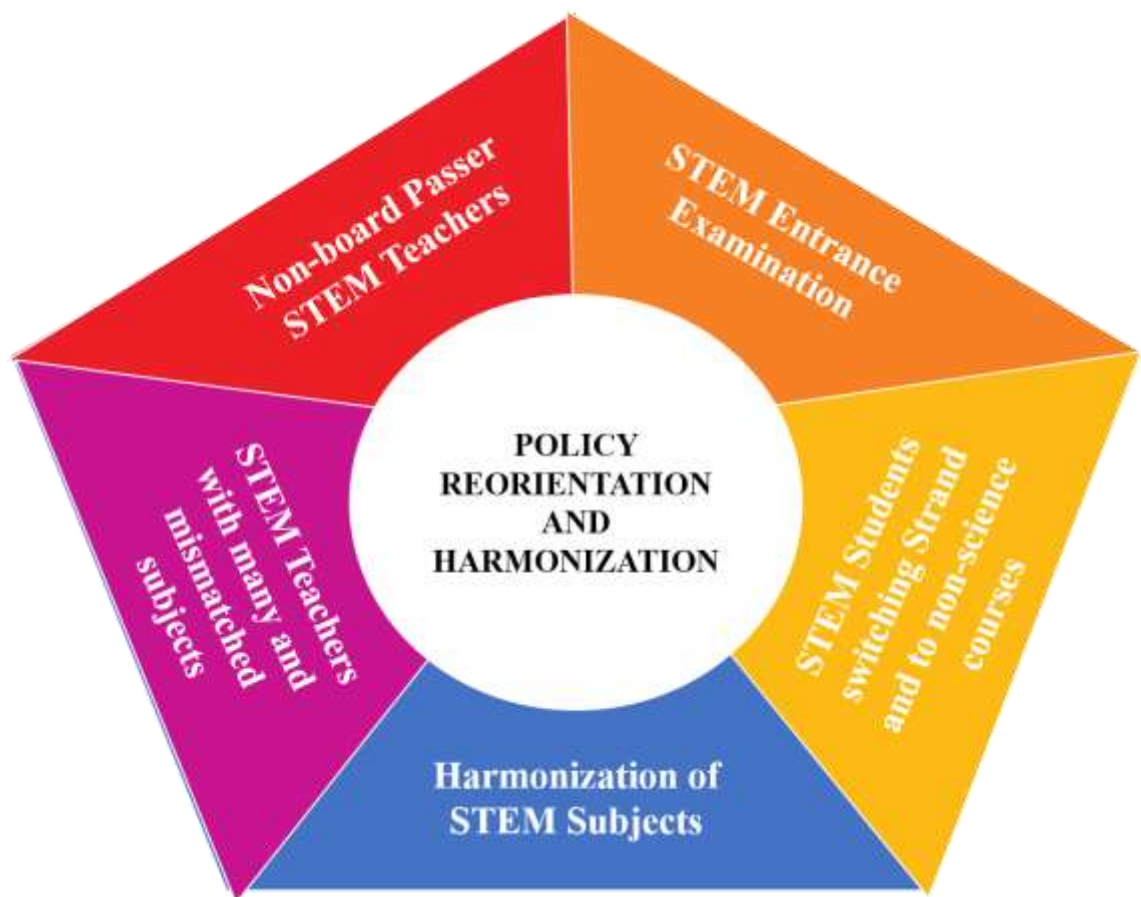


Figure 34. *Concerns of the interviewed teachers and administrators on policies.*



Philippine Normal University National Center for Teacher Education

During the interview, STEM Administrators and teachers mentioned policies that they believe need to be reoriented, changed, included, or harmonized (Figure 34). They believe that these modifications will help the STEM curriculum to develop holistically the students, as well as the teachers and administrators.

Entrance Exam

Among the most talked-about concerns by the participants is the provision of an entrance examination. As of the moment, only a few schools in the Philippines prescribe a student to take and pass an entrance examination for the STEM strand while most of the schools did not conduct any entrance examination.

DepEd Order No. 55 s. 2016 also known as *“Policy Guidelines on the National Assessment of Student Learning for the K to 12 Basic Education Program”* requires a criterion for incoming STEM Strand students to have a final grade of at least 85 in their Mathematics and Science subjects during their Grade 10. In addition, the said department order requires incoming STEM Strand Students to have a percentile rank of at least 85 in the STEM subtest in their career assessment examination conducted during their Grade 9. The two requirements must be satisfied before a student is admitted to the STEM Strand.

Many participants appreciate the fact that only the STEM strand has the grade requirement for admission of students as shown in Table 16. Admin Lars shared,

“The standard of our curriculum is high. That's what I think of STEM. First of all, this is the only strand that the students are screened, there is a cut-off grade. Unlike other strands that whoever likes the strand can enter.



Philippine Normal University
National Center for Teacher Education

So, this is the only strand that you should have a grade of at least 85 in Math and Science.”

Table 16. Criteria for admission of students in different SHS Tracks/Strands (DepEd Order No. 55 s. 2016)

Criteria	SHS Tracks/Strands						
	Academic Track				Sports Track	Arts and Design Track	TVL Track
	STEM	ABM	HUMMS	GAS			
Scholastics Grades at Grade 10	Final Grade of 85 and above both in Science and Math	None	none	None	none	None	None
Career Examination Results	Percentile rank of at least 86 in the STEM subtest	None	none	None	Percentile rank of at least 51 in the corresponding career subtests		None

In the school of Teacher X, the STEM Students are treated somehow as an “elite” students because they are filtered and are doing great in their academics. The students in their school are well informed that one cannot be a STEM student without satisfying the requirements. He shared,

“Our JHS Students are aware of the requirements to be admitted in STEM Strand, that is why, when they are in their Grade 10, they give their best performance in Math and Science to ensure that their grade is included in the cut-off.”



Philippine Normal University National Center for Teacher Education

However, they think that this is not enough since there are students who they think should not be on that track because of their performance. They think that some students are not fit for the STEM Strand due to their dismal grades and outputs. Thus, the need for entrance examination as a requirement for admission is stressed by some of the participants. An entrance exam serves as an indicator of the relative readiness of the incoming students to the STEM Strand. With this, participants think that an entrance exam as a requirement in admission must also be added to DepEd Order 55, s. 2016.

Admin Rina and Admin Jed stressed this need since according to them, there are some students who are not serious about studying in the STEM Strand. Admin Alfred also noted this need, he commented, *“STEM Curriculum is great but we need to be stricter when it comes to admission of the STEM students.”* The same situation is observed by Teacher X, he said,

“I think there should have been a sort of entrance examination because there are students who when they see a friend in STEM, they will also take it and at the middle of the semester, it will just create a problem.”

The proceeding discussion will explain what the problem Teacher X is talking about.

STEM Students switching Strand and to non-science courses

A dilemma on STEM students changing their tracks during their SHS and after graduation looms in the curriculum as revealed by the participants during the interview. Teacher X pointed out that he proposed an entrance exam to be adopted since there are



Philippine Normal University National Center for Teacher Education

students who transfer to other strands in the middle of the semester or school year. He said,

“There are students who would talk to you that at the middle of the semester that they don’t want to pursue their SHS anymore in STEM Strand. When I asked them why they just reason out that they realized that STEM strand is no longer fit for the course they want in college.”

Some students are enrolled in STEM Strand because some of their friends take the same strand or because of the students’ parents’ preference. Some teachers lamented that they could advise students to their preferred courses if only an entrance exam or interview was conducted before admission. The STEM students opt to shift to other strands such as HUMMS and ABM. Teacher Pooh made an analogy, she said, *“They are being thrown into an ocean, but they do not know how to swim.”* The students would be required to take their missed subjects for that strand if they decide to switch. There are options on how the student may take these missed subjects. First, the student may take the additional subjects with the regular subjects offered in the semester or quarter. The class for the additional subjects will be scheduled after the regular school class hours. Second, the missed subjects may be taken through modular instruction or maybe scheduled during summer classes. The last option is to take the missed subjects during the vacant time but with utmost teacher supervision and will be conducted as a special class session (Bandao, 2019). However, the options have proved to be difficult for both teacher and student. Thus, the participants believe that this is just a waste of time and effort for both the students and teachers if a student will transfer to another strand.



Philippine Normal University National Center for Teacher Education

There are also concerns about graduates of STEM Strand taking up non-STEM field courses at the tertiary level. Teacher Jordz recollected that there are instances when his STEM students after graduation will take up Accountancy courses. Admin Rina also noted that few of their students took Education or Fine Arts courses. Even though they admit that there are only a few cases in a batch, this is still much of concern.

Commission on Higher Education (CHED) also has taken concern on this issue by crafting CHED Memorandum Order 15 s. 2017 titled *“Policy on the Admission of Senior High School Graduates to the Higher Education Institutions Effective Academic Year 2017 -2018.”* The policy states that students shall be admitted to any course at the tertiary level regardless of their taken strand or track during their senior high school. However, the same policy also stipulates that Higher Education Institutions (HEIs) may provide admission requirements for any case that some universities adopt stringent measures such as exams for each course to determine or select the students who are eligible and ready for the course. Some universities allow students to enroll in any course without any other additional requirement while some employ bridging programs, which contain additional courses or subjects for the students who are mismatched or misaligned with their SHS track and intended college course (Tupas & Matsuura, 2019). With these additional subjects, the students must demonstrate the competencies required for the course. For example, STEM students who want to take an Accountancy course must take economics, marketing, and business finance courses through the bridging program of the university.

The participants believe that this bridging program is a waste of money and time. With the bridging program, the student will be delayed as much as one semester to finish



Philippine Normal University National Center for Teacher Education

the course since they need to take these bridging subjects. Also, the effectiveness of the STEM Strand is put into question since something is wrong with why other students take another course not related to the strand. This is in consonance with the statement of Admin Airam Berns,

“The problem is when students had wrong decision to take the STEM Strand and then after graduating or finishing the senior high school, the student realized that he or she is not for a STEM-related course in college, so that really be a waste. Yet, we could also infer that there may be hidden problem in the STEM Strand why the students shift to non-science courses when they enter the tertiary level.”

There are many factors that can influence a student in their career choice. Family members can have an impact on the student’s decision and the study suggests that mothers are the most influential among all the family members (Mtemeri, 2017). School can also influence students in their decision-making for their career track. Also, as emanated in the interview and consistent with the literature (Faiter & Faiter, 2013; Naz et al., 2014), students are influenced by peers and friends. Aguado, Laguador, and Ligerio (2015) found out that mentors or teachers can significantly affect the student’s choice of careers since they are the direct example of what the student would be after getting the course. On the other hand, Morales, Avila, and Espinosa (2016) noted that gender could be a factor affecting the student’s decision-making regarding their course. For STEM students in the Philippines, Rafanan, de Guzman, and Rogayan (2020) confirmed that family and peer influence and inspiration from teachers indeed affect the career decision of students. However, their study revealed that personal aspiration is the primary reason



Philippine Normal University National Center for Teacher Education

why students take the STEM strand. Better job opportunities and high salaries in the STEM field were also considered factors.

Andrada and David (2020) conducted a study on the lived experiences of STEM students. They revealed that STEM students switch to a different strand due to the heavy requirements, the anxiety of getting low grades, and unpreparedness. The students' low self-efficacy, high expectations, and peer pressure led them to look for a different career track. In addition, interest, aspirations, enjoyment, and career goals made them decide to shift from the STEM field to a non-STEM. Further, "most of the participants expressed no interest in retaking STEM if given a chance recalling how they coped with the requirements and the subjects" (p. 84). Thus, students who graduated in STEM Strand did not take STEM courses when they went to tertiary level due to the mentioned reasons. In this light, Andrada and Marasigan (2020) recommend that for students' success, social support especially from family, teachers, and peers, more activities outside the classroom, and maintaining high self-efficacy for the STEM students are essential.

Non-board passer teachers

DepEd Order (DO) No. 3 s. 2016, also known as "*Hiring Guidelines for Senior High School (SHS) Teaching Positions Effective School Year (SY) 2016 -2017*," set the minimum requirement for permanency as bachelor degree majoring in the relevant position and if not Board Licensure Examination of Professional Teachers (BLEPT) passer, they must pass the said licensure examination within five years of hiring. Some of the provisions on these guidelines changed through DO No. 27 s. 2016 [*"Qualification*



Philippine Normal University National Center for Teacher Education

Standards for Senior High School (SHS) Teaching Positions in the Department of Education (DepEd)”, DO No. 32 s. 2016 (“Addendum to DepEd Order No. 3, s. 2016”), DO No. 49 s. 2016 [“Guidelines on the Hiring of Contractual (Full-time and Part-time) Teachers in Senior High School”] and finally through DO No. 51 s. 2017 (“Amended Qualification Standards for the Senior High School Teaching Positions in the Technical-Vocational-Livelihood Track and Other classifications on the hiring guidelines”). However, the changes did not modify the requirements of having a licensure examination. The changes only state that teachers without a professional license will be hired as contractual and will be given a considerable amount of time to take the exam and failure to do so will make their item vacant. These hiring guidelines provided an impact to the DepEd system as many could teach in STEM Strand without the necessary licensure examinations. Even private schools could hire teachers without the BLEPT. This is in contrast with the Higher Education Institutions wherein the minimum permanency requirement is a master’s degree and relevant licensure examination.

Interviewed administrators are troubled with this policy since they believe that STEM students should receive quality education from qualified teachers. They claimed that the STEM strand is very special that only capable and competent teachers must teach the students. By being capable and competent, they believe that teachers must already pass the licensure exam before teaching in the STEM Strand. Admins Rina, Spiderwoman, Jam, and Chard shared the same problems that they have teachers who are non-licensed or non-board passers. Admin Rina has teachers who graduated in BS Chemistry, BS Biology, and BS Civil Engineering but without a professional license in



Philippine Normal University National Center for Teacher Education

teaching and they are still in the process of getting professional education units. This is also the same case for Admin Jam who have teachers who are graduates of BS Biology and BS Nursing. They claimed that in terms of content, their teacher has no problem. However, their main issue is with the pedagogical techniques they employed although they are engaging and communicating teachers (See theme Pedagogical Characters). They observed that sometimes teachers without professional licenses employ the same teaching techniques and are novice in classroom management, which is fundamental in the teaching-learning process. Admin Rina shared,

"I do not underestimate the ability to teach of non-education graduates. In fact, there is a big advantage sometimes that they really come from the field. The three are able to integrate practical lessons and activities based on the actual application of the topics, particularly, in the medical field. And it is not just the concept that the textbook provides. But since they lack the prescribed licensure exam, they also lack pedagogy. It's really different if you are really a graduate of education and have a professional license, right?"

Meanwhile, Admin Chard has a teacher who is an education graduate but has no professional license yet. When asked by the researcher if this teacher already took the BLEPT, he answered that this teacher took the exam but failed thrice in a row. Also, the students complained that this teacher taught the wrong concepts and did not teach regularly. Further, when Admin Chard conducted classroom observation, he noted that the teacher lacked enthusiasm in teaching. Admin Chard added,

"The teacher is always low in student's evaluation. I do not know how this teacher passed the hiring committee."



Philippine Normal University National Center for Teacher Education

Tupas and Matsuura (2019) noted that very few were qualified to teach in the SHS using the Civil Service Commission (CSC) and DepEd hiring guidelines, thus, DepEd hired teachers without a professional license to fill the gap of the scarcity of teachers. A study by Taneri and Ok (2014) revealed that teachers without licenses significantly experience more classroom teaching problems than licensed professional teachers. In addition, knowledge level on subjects is significantly higher for licensed professional teachers. Moreover, the study shows that inadequate knowledge among the teachers without license results in frequent negative or wrong decisions in terms of classroom management.

Clotfelter, Ladd, and Vigdor (2011) proved that students who had been supervised by a teacher with no professional license have low academic achievement compared with the students taught by licensed professional teachers. This is also proven in the study of Hawk and colleagues (2015), as cited in Kusumawardhani (2017), wherein they compared teacher's knowledge on the subject, teachers' competencies in the field, and effectiveness on the students' achievement of two groups of mathematics teachers (with license and without a license). Each group of 18 teachers taught the same mathematics subject for seven months for students whose pre-test scores were not significantly different from each other. The results showed that students taught by mathematics teachers with professional licenses got a significantly higher result on algebra and general mathematics than students taught by mathematics teachers without a license. In addition, mathematics teachers with licenses scored significantly higher in a test conducted by the researchers than the other group. The authors argued that mathematics teachers with



Philippine Normal University National Center for Teacher Education

licenses “knew more mathematics and showed evidence of using more effective teaching practices than did their counterparts.” Thus, they conclude that licensure examination is an “effective mechanism to assure higher student achievement in mathematics.”

Teachers handling many courses and misalignment of subjects with their specialization

Another policy that teachers and administrators alike request is that teachers should be teaching their expertise and the prohibition of giving them too many subjects. Teacher Cza, a Mathematics Teacher in a private school, teaches nine different subjects in their school. She handles General Mathematics, Pre-calculus, Basic Calculus, Probability and Statistics, Physics 1 and 2, Biology 1 and 2, and Empowerment Technologies. For her, teachers should teach subjects on their expertise since problems crop up when teachers handle subjects out of their field. This is also the situation of Teacher Jassen, a teacher in private HEI, whose expertise is in biology but she is required to teach General Chemistry 1 and 2. She shared that she grabbed the teaching load since she needed work and money. According to her, she is exerting all her efforts to teach Chemistry and she found it hard during her first year of teaching that she wanted to resign since the topics needed expertise. Both Teachers Cza and Jassen expressed their concern that they could not give the competencies that the students must get in the subjects. Also, they feared that they may create misconceptions and would not be able to clarify some points. Teacher Cza recalls a case where she failed to answer a probing question on Biology asked by one of her students. She shared that teachers must be at least one



Philippine Normal University National Center for Teacher Education

chapter advanced in terms of topic, but she could not do it in her case since the subject is difficult. When Teacher Jassen was asked how she was able to teach Chemistry in her class, she replied,

“I am just teaching on what is in the syllabus. I cannot add more since the fundamentals are hard, so how can I add more? I just kept in my mind that the students should know these terms and these chemistry concepts.”

Teacher Michael, a graduate of Bachelor of Secondary Education major in Physical Sciences, also complained that he teaches media literacy while he should be teaching only Physics or Chemistry. Interviewed teachers believe that the learner’s experience can become more meaningful and richer if their teachers are experts on the subject matter. Teachers Michael, Cza, and Jassen are concerned about their preparation and the challenges in preparing and planning the lesson they are unfamiliar with and are beyond their expertise in a short time. Thus, they claimed that they are uncomfortable; they feel anxious, and they have low self-confidence in teaching these subjects. This mismatch or misalignment also causes their struggle in giving authentic real-life learning for the subject. This experience is consistent with the study of Attia (2017) that “when teachers are not comfortable with a subject area, it affects their effectiveness, as it consumes them more time, work, and effort to prepare and deliver their lessons, in contrast to teaching subject areas that they are familiar and comfortable with (p. 9).”

Admin Jam confirmed that the mismatch of what the teacher teaches and with the teacher’s field of specialization also happened in their school. She commented that they do not have a teacher with a specialization in Chemistry, thus, she gives the teaching load



Philippine Normal University National Center for Teacher Education

to their teacher who graduated with the degree of BS Biology. Meanwhile, the Biology subjects were given to her teacher who graduated BS Nursing. Moreover, she shared that some of her teachers do not want to teach Physics so she was forced to request a Mathematics teacher or someone who has the courage and who wants to teach the subject.

Studies revealed that the bachelor's degree of the teacher is commonly the area of their expertise and the source of their subject matter knowledge. Shulman, known for his work on the teachers' knowledge, claimed that deep understanding and excellent subject-matter knowledge are elements of effective teaching since teachers are comfortable explaining and demonstrating a topic, thus, empowering the students to achieve (Jadama, 2014). The teaching effectiveness of the teachers is being affected when they have no confidence in what they teach as they tend to "avoid having to answer the students' deep questions, spend less time on the subject, and avoid the use of practical and innovative tools" (Johannson & Myrberg, 2019, p. 189) which eventually cause negative effect on students' achievement.

The inability of teachers to answer questions of students may result in disappointment for students who aim for challenges and may also impede intervention for struggling students (Erskine, 2010). In his study, Peace (2012) revealed that mathematics and science teachers should have profound and better understanding of the content or subject matter knowledge than average individuals. He added that "deeper understanding of the content is required from teachers who can answer content questions and not just have knowledge in pedagogical practices" as the opposite may lead to flawed teaching.



Philippine Normal University National Center for Teacher Education

Harmonization of subjects

Not only in the mismatch or misalignment of subjects they teach with their expertise that teachers have a problem but also with the subjects already taken by the STEM students. There are cases that a STEM student transfers from a private school to a public school or to an HEI or vice versa. It turns out that not all schools have the same subject offerings every semester. The various schedules of subjects offered in the STEM Strand create confusion, concerns, and issues for the teacher and administrator as revealed in the interview corpus. Interviewed participants shared that student-transferees experience difficulty in the new school since the subjects are not the same for both schools.

For integrated SHS and stand-alone SHS with STEM Strand, many schools follow the prescribed scheduling of subjects by the DepEd. The problem lies with the private secondary schools and public and private HEIs with STEM Strand. This is because these schools may modify or add certain subjects for what they deem fit for their students as long as the minimum required subjects are met. However, due to this addition or modification, their subject offering every semester also changes.

Teacher DeoGirl, a public HEI teacher, shared that in their school, General Chemistry 1 and 2 were offered during the 1st semester and 2nd semester of Grade 11, respectively, unlike with that of DepEd schools wherein these subjects were offered during the 2nd semester of Grade 11 and 1st Semester of Grade 12. Teacher Joe, a private school teacher, also has the same dilemma as their Practical Research 1 and 2 are offered



Philippine Normal University National Center for Teacher Education

earlier than in DepEd. Thus, when their student transfers to other schools, the student may expect a hard time adjusting and targeting graduation on time. This situation is also the case when a student from another school transfers to their school.

Table 17 shows the subject offerings of some SHS STEM Strand Schools in Nueva Ecija for the Grade 11, 1st semester. It revealed that most schools have the same core subjects but different in applied and specialization subjects. School A has an additional specialization subject for their offering in Grade 11, 1st semester subjects, while School B modifies the subjects for applied and specialization compared to the subject offerings of DepEd schools.

Teacher X experienced a case wherein he was teaching a topic in General Physics requiring knowledge in Calculus when he noticed that a transferee student was having a hard time coping with the lesson. When he asked the student about the problem, he found out that the student is not yet done with the Basic Calculus originally offered in the 2nd semester of Grade 11 since the student's previous school offers it during the last semester of Grade 12. He commented, *"It is hard for me and the student since the prerequisite of Physics is Calculus. He will not understand the topic if he does not have a fundamental knowledge of Calculus. It is so chaotic."*



Table 17. Subject Offerings of Some Schools in Nueva Ecija for STEM Grade 11 1st Semester

Grade 11 STEM Subjects 1st Sem	DepEd Schools	School A (a Public HEI in Nueva Ecija)	School B (a Private school in Nueva Ecija)
Core Subjects	Oral Communication in Context	Oral Communication in Context	Oral Communication in Context
	Komunikasyon at Pananaliksik sa Wika at Kulturang Pilipino	Komunikasyon at Pananaliksik sa Wika at Kulturang Pilipino	Komunikasyon at Pananaliksik sa Wika at Kulturang Pilipino
	General Mathematics	General Mathematics	General Mathematics
	Earth Science	Earth Science	Earth Science
	Introduction to the Philosophy of the Human Person	Introduction to the Philosophy of the Human Person	Introduction to the Philosophy of the Human Person
	Physical Education and Health	Physical Education and Health	Physical Education and Health
	Empowerment Technologies (ETech): ICT for Professional Tracks	Empowerment Technologies (ETech): ICT for Professional Tracks	<i>Practical Research 1</i>
Applied Subjects	Pre-Calculus	Pre-Calculus	<i>General Biology</i>
		<i>General Chemistry 1</i>	

With this problem, some of the interviewed teachers and administrators call for harmonization of subject offerings nationwide in all types of schools offering STEM Strand. Admin Jed lamented,

“Hopefully, STEM course offerings will be consistent for both public and private every semester because we have so many problems. We have



Philippine Normal University National Center for Teacher Education

transferees from other provinces or from private schools who come to us. We have no right to reject transferees. Our problem is that they did not get the same subjects. There are schools that offer Physics first, while some already get their General Biology in Grade 11 while it is supposed to be in Grade 12. I hope there will be a mandate from DepEd that in Grade 11 first semester, these should be the subjects to be offered, and when it comes to the second semester, these should be the subjects. This will harmonize the subject offerings so that teachers and student transferees will have no problem."

Non-DepEd schools such as private and high-schools in HEIs are allowed or have a leeway to modify and alter their subject offering as long as the minimum required competencies or subjects are met and they inform the Department (Padilla, 2013). DepEd Order 31 s. 2012 titled "*Policy Guidelines on the Implementation of Grades 1 to 10 of the K to 12 Basic Education Curriculum (BEC) effective School Year 2012 – 2013*" stipulated that "private schools may further enhance the curriculum to suit their school vision/mission" (p. 1). This leeway of private school is extended into senior high school as provided in DepEd Order No. 4 s. 2014 [*"Guidelines on the Preparation for the National Implementation of the Senior High School (SHS) Program in Non-DepEd Schools for the School Year (SY) 2016 -2017 and Onwards"*]. This is consistent with DepEd Order No. 88 s. 2010 also known as "*2010 Revised Manual of Regulations for Private Schools in Basic Education*" wherein Section 9.1 states that

Section 9. Curricular Programs.

"The curricular programs shall be suggestive patterns and models for the guidance of field officials and teachers. These may be enriched or modified to suit the needs of the learners and the conditions in the school and community, provided however, that any radical departure from the specified subjects and curricula shall have the approval of the Secretary of Education."



Philippine Normal University National Center for Teacher Education

Ideally, public and private HEIs follow CHED Memorandum Order No. 35 s. 2016 otherwise known as “*Guidelines for Operation of Senior High School (SHS) in State Universities and Colleges (SUCs) and Local Universities and Colleges (LUCs)*” in their operation of senior high school in their respective schools. The memorandum provides a modification of subject offering but must still be consistent with DepEd and that HEIs on a trimester basis must divide their subjects into three terms and not shorten the SHS years. Hence, their students must still finish SHS within two years even though the HEI is on a trimester basis. HEI also has different policies and requirements in terms of enrolments with other HEIs since their policies are governed and approved by their respective Board of Regents as long as it is consistent with the CHED, CSC, and other relevant agencies policies.

11. Support and partnership

Non-school persons such as parents and the community play major roles in the education curriculum of a country. They provide support in making the schools conducive for teaching-learning activities. A variety of support programs were planned, created, and implemented to facilitate students’ successful progression through the STEM Curriculum. The support is deemed important by the participants for an effective learning process of students (Figure 35). The teachers and administrators are integral parts of the educational system. Teachers and administrators provide support to their students, likewise, teachers also need institutional, parents, and community support. The institution



supports its teachers and administrators while strengthening their linkages to the parents and the community.

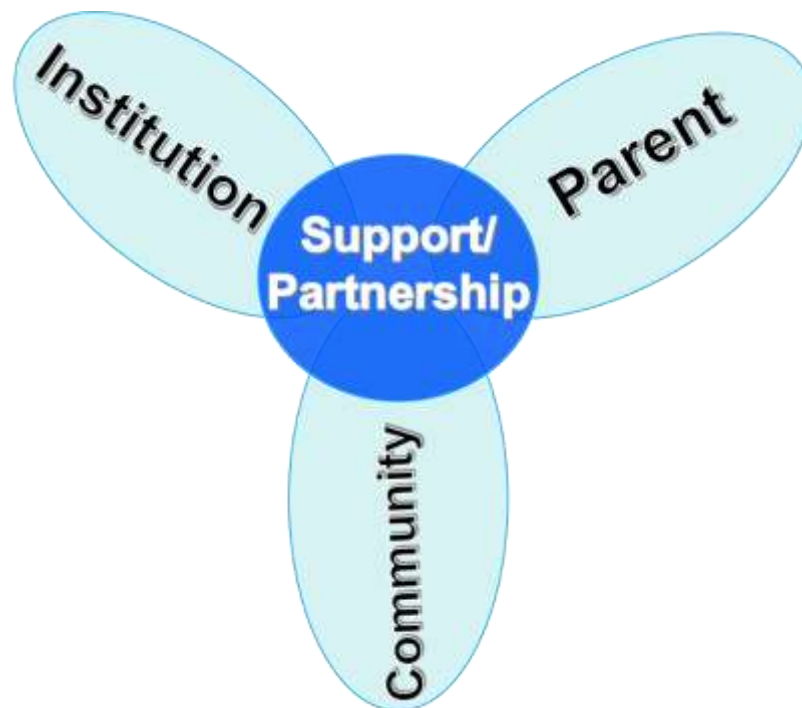


Figure 35. *The triad of support as expressed by the participants.*

Institutional Support

Interviewed STEM Teachers and administrators claimed that their respective institutions are supporting them largely on capacity-building activities. They claimed that they receive enough training, workshops, and seminars to develop their skills and update their capability in teaching for teachers and supervising for administrators. The institutions provide financial support for teacher professional development programs



Philippine Normal University National Center for Teacher Education

(TPDP) which can be categorized into internal and external. Participants claimed that they could participate through their institution in various external TPDP such as regional and national symposia, training, and seminar workshops outside their schools. Internal TPDPs that the institution provides include Learning Action Cell (LAC), In-service training (INSET), and peer mentoring or coaching of other teachers, among others within their school. Their respective institutions are also supportive of the participation of STEM teachers and administrators in online courses. However, there are schools that send few participants in training and they are chosen by their principal or supervisor. This practice created an unfavorable setting in such a way as observed by the researcher. One interviewee who is hesitant to say this fact shared that in the school where he was employed, his principal is unsupportive of him in terms of his professional growth for STEM Strand. When he was asked if he has attended training or seminars through the course of his employment, the interviewee answered none. In the latter part of the interview, he finally shared that one of his co-teachers is always being sent to participate in the seminars. The interviewee stated, *"We all think that she is the favorite of our principal."* When the researcher confirmed this information with his immediate supervisor, it was established that the principal selected the teacher to be sent on the training based on several criteria, not because of the alleged favoritism.

The TPDP is important especially for newly hired teachers and non-education graduate teachers since they are being upskilled in their behavior management and pedagogical knowledge development. Some participants also shared that some of the seminars they participated in focused on enriching their content-based knowledge. New



Philippine Normal University National Center for Teacher Education

and experienced teachers need support in the lifelong learning competencies as the STEM Curriculum in our country is relatively new. The STEM Curriculum can still be considered in the early stage of the implementation; thus, teachers and administrators are still grasping the situation. The various enrichment programs will help them contextualize and be acclimatized to the curriculum.

Participants also claimed that the support of their schools is evident in the provision of resources such as LCD Projector, markers, printer, and coupon bond. Moreover, they acknowledge the support of their school in approving rest and recreation activities such as team building activities on a regular basis. They appreciate that their institution ensures that they are well-rounded individuals by giving opportunities for their mental health enrichment so that they will be healthy mentally and emotionally as well.

Parent involvement

Parents are known supporters of the curriculum. They are the most concerned if their child receives the best education from the school (Olibie, 2014). The essential role of parents to teachers and students' academic success should be credited. According to the participants, the early engagement of the parents-teacher relationship has been identified to be effective when it comes to the institutions' success systems and programs. The programs are those devoted to socio-emotional development, learners-school readiness, and support on academic achievement. Kyriakides and colleagues (2015) reported that learners choose to stay at school longer and perform better in school when they get through their holistic senses the signals of the harmonious working relationship



Philippine Normal University National Center for Teacher Education

of their families, school, and community group to support education. The result of this fact can be observed in some areas like attendance, positive behavior or social skills, and the increasing enrollment rate of learners in the track. The school cannot work without support from parents. It always finds ways to strengthen the level of parent engagement to achieve targeted outcomes (Bonell, Sundaram, & Viner, 2021).

Most schools engage parents through the Parent-Teacher Association or PTA. Parents can influence the school and its curriculum because they can monitor and assess the performance of their child's work especially in homework activities. Teachers Maestro and Alfred mentioned that parents are the ones who decide the most in the work immersion of students. Some parents found the location of their child's work immersion impractical and uneconomical since the agency wherein their child will be situated is far from their home. Thus, collaboration among parents is practiced heavily by the interviewed teachers to come up with good decisions. The participants always tell the parents that they are both in-charge of the welfare of the student. Parents also donate some physical facilities in the classrooms such as an electric fan, air-conditioner, and television for the comfort of their children. These parents' supportive behavior definitely creates a conducive learning environment for the students. Teacher X noted this behavior,

"Parents are very supportive, Sir. They are positive about our request like instance there was a time that I asked for approval of a project for the welfare of the students, they immediately approved it because they saw the benefit. They understand us."



Philippine Normal University National Center for Teacher Education

Notable support of the parents is their volunteerism during the Brigada Eskwela of DepEd also known as “National Schools Maintenance Week.” Through this activity, the DepEd hopes to show not only to the parents but also to the community as a whole that education is a shared responsibility among the stakeholders.

To increase the level of parents’ engagement in school, the administrators and teachers should understand how parents should think and this could be done by communication. In this way, a teacher could understand and execute effective strategies on how to get access to students dealing extensively with their uniqueness and diversity. Parents would be the key person on how to unleash and unlock the potentials of the learners in a significant field, and such contribution will lead to curriculum development and innovations (Oostdam & Hooge, 2013). Appreciation to the wonders of communication with parents partakes to the idea of having an improved channel responsive to parents’ needs, interests, and concerns mainly about their child. It is a fact that most parents exclusively depend on the scores of their child in seat works, various activities or performances, and written examinations to determine whether or not such academic progress has been achieved, but this plain view should be analyzed and well-discussed with parents through communication to promote understanding and to connect to the rationale of the given forms of assessment (LaRocque, 2013).

There could be a challenge in finding the “balanced communication” between the teacher and parents’ connection, parents’ relation to formal evaluations, power of parents in terms of collaborating support in the curriculum designing and school community. The



Philippine Normal University National Center for Teacher Education

researcher believed that parents could change the educational scene to come up with a curriculum framework suitable to the ever-changing demands of society.

Community Partnership

Community, specifically industry, is one of the stakeholders which gives life and action to the STEM curriculum. In the *STEM curriculum*, the teachers complain about the scarcity of resources such as facilities, books, and other learning materials. In this case, participants revealed that they sourced out this deficiency from the community. Teacher Bart shared that since his school lacked facilities for a laboratory, he toured his students in different science agencies nearby their school. Also, Teacher Joe revealed that when there are chemical reagents or materials that are needed in the experiment but not available in their school, they will request it from the university or other science laboratories.

Local government units (LGUs) as part of the community surrounding a school also provide support by supplementing financial means in the school through the utilization of the Special Education Fund (SEF). This budget came from the one percent of the real property tax collected by the LGUs which is a significant amount considering the collection of the local government (Manasan, Celestino, & Cuenca, 2011). Hence, LGUs are considered major supporters of DepEd in giving quality basic education services (Mallari, 2017). Interviewed administrators highlighted this support in their hired teachers of the Local School Board (LSB) headed by the Mayor and Schools Division Superintendent (SDS). The LSB-hired teachers get their salary from the LGU charged to



Philippine Normal University National Center for Teacher Education

SEF. Also, interviewed administrators mentioned the importance of SEF in their sports development and co-curricular activities. The repair and construction of school buildings were also requested in the LGU through SEF.

Meanwhile, politicians, alumni, and Non-Government Organizations (NGOs) also contributed to the school's development through donations of equipment such as information technology resources. In addition, these benefactors give support on the upgrading of facilities and classrooms. Admin Armier shared that their school library building was constructed from the donation of their alumni. The science laboratory facilities in the school of Admin Spiderwoman were improved through the financial assistance of their municipal councilor.

The participants also identified the community as the biggest factor contributing to the STEM students getting the necessary skills and having an attitude and behavior of a scientist, engineer, or mathematician. The community is the teachers' major source in getting speakers such as well-known scientists and engineers. Through this, the students are motivated because they meet people worthy of emulation in their chosen tracks. Further, through the local government, they receive support in building, donations, and other school materials.

Moreover, the partnership of schools in community and industry is a key factor in how the Work Immersion of the students could be successful. DepEd's main goals in providing Work Immersion are for the students to be able to: "gain relevant and practical industrial skills under the guidance of industry experts and workers; appreciate the importance and application of the principles and theories taught in school; enhance their



Philippine Normal University National Center for Teacher Education

technical knowledge and skills; enrich their skills in communications and human relations; and develop good work habits, attitudes, appreciation, and respect for work” (“Work Immersion, 2017, p. 1). Without the partnership from the community, these goals will not be achieved and the students will not be prepared for employment or tertiary education after their SHS graduation. The DepEd reiterated the importance of building partnership with the community through its DepEd Order No. 40 s 2015, also known as “*Guidelines on K to 12 Partnership*.” In this order, DepEd recognizes the role of the community in helping the schools in job opportunities for the SHS students, additional resources, hands-on expertise, and livelihood opportunities. To also help its external stakeholders particularly its private donors, DepEd provided instruments to enable donating entities and schools to benefit mutually from their partnership. The crafted DepEd Order No. 24 s. 2016 otherwise known as “*Guidelines on accepting Donations and on processing applications for the availment of Tax Incentives by Private Donor-Partners supporting the K to 12 Program*” aims to provide details and guidelines for the tax incentives in accordance with Republic Act No. 8525 (“*Adopt-a-school Act of 1998*”) and Bureau of Internal Revenue (BIR) Regulations No. 10-2003 (“*Implementation of Tax Incentives Provision of Republic Act No. 8525*”).

The interviewed STEM teachers and administrators considered themselves and their students lucky because the province of Nueva Ecija is the home of many science agencies. Thus, they have no problem in establishing linkages with these agencies through the Memorandum of Agreement (MOA) and Memorandum of Understanding (MOU). Admin Lars remarked,



Philippine Normal University National Center for Teacher Education

“We are happy that these agencies are very helpful and willing to collaborate. Hence, our students experience the true nature of the work of scientists and engineers when they are going to these agencies. A real-life experience with these people is something our students need to become motivated.”

The Province of Nueva Ecija housed the only Science City in the Philippines and second to the world after the Tsukuba Science City of Japan, the Science City of Muñoz. The city is declared as such by virtue of Republic Act 8977 (*“An Act Converting the Municipality of Muñoz in the Province of Nueva Ecija into a Component City to be known as the Science City of Muñoz”*) with the promising status of this city in the modernization of science and technology. The term “science city” was achieved by the municipality since it housed various local and national science and research institutions in the country. These institutions have state-of-the-art facilities and competent scientists who are champions of technological advances. The national agencies include the Philippine Rice Research Institute (PhilRice), Philippine Carabao Center (PCC), Philippine Center for Postharvest Development and Mechanization (PhilMech), National Freshwater Fisheries Technology Center (NFFTC) or Fresh Aquaculture Center (FAC), The Philippine-Sino Center for Agricultural Technology (PhilSCAT), National Small Ruminant Center (NSRC), and Ramon Magsaysay Center of Agricultural Resources and Environmental Studies (RM-CARES). The local institutions in the Science City of Munoz which main focus is research and development include Central Luzon State University, Nueva Ecija Fruits and Vegetables Seed Center, The National Irrigation Administration and Casecnan Multi-Purpose Irrigation and Power Project, Bureau of



Philippine Normal University National Center for Teacher Education

Fisheries and Aquatic Resources (BFAR) Region III, Soil and Water Resources Management Center, Regional Science Teaching Center, Department of Science and Technology (DOST) Nueva Ecija, and Department of Environment and Natural Resources – City Environment & Natural Resources Office (DENR-CENRO). These institutions serve as avenues of advancements and innovations with the goal of producing science and technology-equipped Filipinos.

With these institutions, the STEM students and teachers particularly in the Division of Science City of Munoz have founded linkages and partnerships. Also, other divisions in Nueva Ecija take time to visit and enter into MOA and MOU for their students. Thus, the STEM students and teachers in Nueva Ecija through the school-community partnerships have various resources and they can choose from among these institutions where the students can take their work immersion.

Emergent themes in relation to STEAM Education

An exploration of the needs and constructs of the SHS STEM Academic track in terms of the pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, and other qualitative parameters was conducted through the lens of the teachers and administrators. The interview of the STEM teachers' and administrators' standpoint on the STEM Curriculum generated open codes and axial codes relevant to the development of the grounded theory. Coding analysis yielded eleven selective codes or themes. They are the following: *teachers' qualifications*, *teacher competencies*, *teacher pedagogical*



Philippine Normal University National Center for Teacher Education

characters, STEM curriculum refinement, discipline-integration, assessment practices, policy reorientation and harmonization, safe learning space, student' skills, administrator' leadership and management, and partnership and support. To create a storyline from the eleven themes in developing the framework or the grounded theory, the interaction and the hierarchies of the themes, categories, and concepts were established. The next paragraphs take into consideration the connections of STEAM education with the themes gathered from the STEM Strand needs and constructs. It facilitates the visualization of the narrative obtained from the data.

Teachers' and administrators' perceptions and viewpoints are essential information in implementing STEAM Education (Maeda, 2011). Thus, to provide information for the possible implementation of STEAM Education in the SHS, a deep understanding of the themes concerning STEAM Education and the science teaching-learning process is necessary. The teaching-learning process in science is significantly challenging as compared to the other subjects. It is a fact that teachers' job is not limited to making their students learn new things but also to unlearn many existing ideas. Different approaches have been devised to achieve this goal, such as inquiry-based learning, flipped learning, STEM Education, STEAM Education, and many others. STEAM Education is the blending of Mathematics, Engineering, Technology, and Science coupled with Arts. Hence, it is the integration of Arts into the existing STEM education framework. STEAM Education is aligned on solving and working in real-life scenarios to develop authentic connections between learning practice and academics.



Philippine Normal University National Center for Teacher Education

The interview revealed that participants perceive teachers' qualifications and competencies as important elements of the STEM curriculum. They affirmed that teachers must have specialization aligned with the subjects in the STEM Strand, as well as having an advanced degree such as master's (MS/MA) and doctor's degree (PhD). Further, teachers should have specialized training on the subject one teaches, a passer of the Board of Licensure Examination for Professional Teachers (BLEPT), and must have sufficient teaching experience. To mention other important elements needed in STEM education that are also relevant to STEAM education, one should consider the following teachers' competencies: subject-matter competency, lifelong learning competency, technological competency, research competency, communication competency, and emotional and self-attributed competencies.

There are notable similar studies abroad that show that qualified teachers perform high-quality teaching especially on STEAM Education targeting the outstanding level of effectiveness in the teaching-learning process. The same output is also true with the teacher's competencies considering that knowledge alone will unlikely develop and harness teachers' competencies. Teachers' knowledge and skills are developed when they gain experiences from their profession. However, subject-matter competency, lifelong learning competency, technological competency, research competency, communication competency, and emotional and self-attributed competencies of teachers are wanting in STEAM Education. These competencies are needed as the teachers are one of the driving mechanisms of a sustainable education curriculum. Competent teachers provide quality education and quality STEAM education as well.



Philippine Normal University National Center for Teacher Education

Many countries experience problems and challenges implementing STEAM Education when educators simply integrate Arts into STEM subjects (Henriksen, 2017). These issues are due to the fact that some science teachers are not artistic while other science teachers could not appreciate the integration of arts in the STEM disciplines. English (2017) reported that teachers are being pressured and overwhelmed by the addition and integration of Arts in STEM disciplines to produce quality STEAM Education. The arts integration and authentic assessment and contextualization in the real-world situation make it hard for teachers to adapt to this new method. Further, the lack of STEAM experiences and exposure during pre-service training of teachers affects their confidence in using the STEAM Approach which is also true in the Philippines if STEAM Education is implemented without the necessary preparation.

Moon (2020) noted four known barriers in implementing STEAM education in which three of them are teacher-related concerns. The barriers include Pedagogical and instructional practices, STEAM implementation decision making, teachers' content knowledge and experience in each STEAM discipline, and the teachers' limited knowledge on applying content knowledge to real-world situations. Moreover, the STEAM Education process involves critical thinking, cooperation and collaboration, communication, and creative problem-solving. Aligned with these barriers and processes, teachers need to have the skills and competencies to incorporate the process in their teaching and for them to be able to become effective. Thus, without the right qualifications and set of competencies, teachers may affect the effectiveness of STEAM Education implementation in the country.



Philippine Normal University National Center for Teacher Education

Aside from the qualifications and competencies, the pedagogical characters of the teachers are perceived to be significant in STEAM Education. The analysis of interview responses emanated three pedagogical characters based on the techniques and strategies STEM teachers employed in their teaching. Communicating Teacher uses interactive pedagogy while Engaging Teacher employs collaborative or cooperative pedagogy. On the other hand, Transforming Teacher utilizes creative, reflective, or critical pedagogy. These characters are the needed qualities of STEAM teachers. The informing teachers that employ telling pedagogy most of the time in their teaching-learning process as they are practiced upon the prior years are now frowned upon and avoided. Telling pedagogy is the technique wherein teachers would only present facts, data, and information to be remembered by the students. Even though the advent of 21st Century learning made the classroom environment more student-centered, there are still teachers who cannot distance themselves from the lecture-discussion method. Informing teachers are the teachers that still uphold the ideal of a teacher-centered classroom. They see themselves as the only authority of the subject matter in the classroom. Learners are considered passive recipients of information and knowledge and teachers are looked upon as the master or expert of the subject matter in the school. Further, the said method is traditional and learners have little or no involvement in the teaching process.

The pedagogical characters of teachers play a crucial role in STEAM instruction. Teachers are tasked to create a vibrant learning environment and provide authentic learning where students can experience real-world applications of the subject through their creativity. Through the different instructional strategies, the mentioned task is easily



Philippine Normal University National Center for Teacher Education

accomplished. Transforming teachers with their creative, reflective, and critical pedagogies have no problem in providing authentic teaching and learning since these are aligned pedagogies in STEAM instruction. This situation also goes with Communicating and Engaging Teachers as STEAM Education promotes collaboration, cooperation, and interaction. However, enrichment of these characters is needed to construct a holistic and complete curriculum with the teachers' effective instruction. This enrichment is beneficial to teachers and has a constructive impact on students.

To discuss more on the characters, the teacher's assessment practices were also brought up to be talked about during the interview. STEM teachers implement DepEd assessment strategies regardless of what type of school they come from. They claimed that formative and summative assessments based on the learning competencies, performance standard, and content standard set by DepEd are the general routine in their classes. They use reflective questions and authentic assessments like simulations, role-playing, and portfolio to promote creativity and innovation among STEM students. However, from the conducted data analysis, it was revealed that they are more familiar with the use of traditional assessment than authentic assessment which may be attributed to their lack of technological competency. Stubbs and Meyers (2015) stated that there is a dire need for student-centered learning, authentic assessment, and project-based learning to implement STEAM Education. The trend in STEAM education assessment is to balance the standardized method with the summative and formative real-life assessment. Many STEAM educators recommend this holistic assessment approach as it reflects real-world practices and experiential tasks to nurture students' academic progress and success.



Philippine Normal University National Center for Teacher Education

Authentic assessments revolve more on interpersonal strategies, problem-solving strategies, questions, and how things are applied in a real-world situation (Herro et al., 2017). Portfolio and performance-based assessments are highly recommended of all the authentic assessments as they give extensive information about student's growth and engagement, as well as, they mirror the teachers' STEAM pedagogies giving a comprehensive picture of the teaching-learning process happening in the classroom. Studies suggest that STEAM education assessment must demonstrate "convergence of practices, processes, and content for diagnostic, summative, and formative assessment purposes" (Huser et al., 2020, p. 16). Teachers need support in appreciating concepts to real-world situations which is very functional in the provisions of authentic assessments in STEAM Education. Good assessment practices could improve teachers' instruction and students learning in STEAM Education. Looking at the current assessment practices of the interviewed participants coupled with their pedagogical characters, their use of assessment strategies to promote innovativeness and creativity among STEM strand students leads to a certain extent of alignment to STEAM Education.

Administrators play a critical role in the curriculum. This role was expressed strongly by the participants during the interview. Administrators shared that they employ more transformational leadership in their supervision. They provide managerial leadership, instructional leadership, strategic thinking innovation, stakeholder engagement, and personal excellence to have sound management and effective leadership. The administrators provide a democratic educational sphere that fosters the professional openness and honesty required for work to understand the shortage in



Philippine Normal University National Center for Teacher Education

teaching and learning. The role is not limited to supervision but also to building harmonious relationships with the teachers. Some of the key undertakings involve listening to the problems encountered, offering advice as needed, and making a formative and summative evaluation of the teacher's performance. Their ability to teach shared responsibility for school improvement and sustenance of collaborative relationships with stakeholders gave positive development in the school they are supervising. This ability helps the curriculum because STEAM Education requires a positive relationship with the teachers and their administrators. In Korea and Vietnam, it was reported that teachers' lack of administrative support in STEAM teaching has an adverse effect on their effectiveness on the curriculum (Hau et al., 2020; Park et al., 2016). Avramides and colleagues (2014) reported that "top-down administrator's level decision" in schools also obstruct STEAM Education implementation because teachers are hesitant to engage in collaboration. In the interview conducted by the researcher, it is noted that "top-down administrator's level decision" is seldom practiced since administrators prefer democratic leadership. Another report in other countries provides that administrators' expertise in the STEM field also affects STEAM instruction when administrators who were non-science majors tend to focus more on the classroom management and general pedagogy rather than on the contents, thereby hampering teachers to improve their instruction and to advance student learning outcomes (Lochmiller, 2016). In STEAM Education, teachers need strong support from the administration "to give them ample resources and time to co-plan and develop instruction and materials that may require more time than a quick lesson" (Huser et al., 2020, p. 14).



Philippine Normal University National Center for Teacher Education

The safe learning space, as one salient theme, is perceived to be on the common grounds of both administrators and teachers. The generic term and ideals of creating a conducive space for students' growth have always been the cardinal consideration in the learning environment. Participants' goal is to provide them with a learning environment free of discrimination and violence. An environment with a sense of belongingness, safety, comfortability, security, and inclusiveness will surely lead to an effective learning process. Hence, teachers and administrators must be vigilant with the environmental factors and classroom climate, especially teachers' classroom management, physical environment, and effective traits of teachers as these factors tend to affect the holistic well-being of learners. In STEAM education, a safe learning space is challenging because it provides settings where students may feel comfortable performing authentic tasks, expressing creative and innovative ideas, thinking outside the box freely, and working cooperatively with others without fear.

Moon (2020) and Kang (2019) contend that information and knowledge about STEM instruction and STEM school implementation provide possible indicators about STEAM Education. Interviewed teachers and administrators described the present STEM curriculum in a contrasting manner. According to them, the STEM Curriculum is *comprehensive yet congested, work-oriented yet very idealistic, and well-designed yet problematic*. Their perspectives in the current curriculum are the following: (a) The STEM curriculum is comprehensive and perfectly planned since all the necessary subjects are present, which can develop their skills, especially in doing research and laboratory works. Likewise, the specialized subjects in the curriculum could be a good



Philippine Normal University National Center for Teacher Education

foundation and can boost the interest of the students to take STEM-related courses. (b) The curriculum is designed for those students who will take up engineering, biology, physics, and other science-related courses. (c) Provision of work immersion in the curriculum enables the learners to apply their skills in real-life settings and makes the students empowered and equipped to become a human resource for economic development. However, participants noted that there are problems in the curriculum as it lacks teachers' and students' guides for specialized subjects, inadequate provision of laboratory materials and equipment, and the lack of laboratory rooms and facilities. They also describe the curriculum guide as rigid as if there is no class interruption, thus, describing the curriculum as "ambitious." In addition, they believe that the curriculum is congested. They attributed this congestion to the number of topics in the curriculum guide, repeated topics from JHS, and the number of subjects students must take in a semester. These issues and concerns of teachers and administrators must be addressed as the implementation of STEAM Education may be hampered by these problems. Refinement of the present curriculum is important as Rapport (2020) argued that STEAM Education is dependent on the foundation of the previous curriculum. If there are problems with the previous STEM curriculum, this may persist and affect the implementation of STEAM education. Thus, the previous curriculum serves as an indicator of the implementation of a new curriculum.

Also, participants mentioned policies that they believe needed certain changes or modifications. They believe that these existing policies hinder the current STEM curriculum for an effective educational process. The researcher listed the reasons behind



Philippine Normal University National Center for Teacher Education

the said policies, and they are as follows: (a) Entrance examination was not the prime determinant for the selection of qualified students for the curriculum because most of the students were not taking their academic responsibility with rigor. So, educators shall look more at the bigger picture which is the academic grade. Participants believe that grade requirement as a prime basis for admission is insufficient. (b) Cases of STEM Students changing their tracks during their SHS and after graduation also looms in the curriculum. Further, the participants claimed that the presence of non-board passer teachers in the Strand lessens the quality of instruction at a certain level for the students. They argued that the STEM strand is a specialized strand requiring an advanced level of teaching that only capable and competent teachers must teach the students. Moreover, there is a clamor that teachers should only teach subjects within their expertise and avoid giving them too many workloads with several and varied disciplines. They claimed that this affects the quality of their teaching. (c) They believe that harmonization of subjects must be made on the STEM Strand within a grade level and within school regardless of its type (public HEI, private HEI, integrated SHS, stand-alone SHS, and private secondary schools). It turns out that not all schools have the same subject offerings every semester which creates confusion for teachers and administrators. Students who will transfer to other schools have experienced difficulty since the offered subjects are not the same in their previous school and new school.

In this light, participants want the policies concerning the aforementioned issues to be reoriented, modified, or changed so that a smooth operation in the curriculum can be attained. Herro et al. (2019) noted that conflicting issues about national and regional



Philippine Normal University National Center for Teacher Education

policies serve as hindrance in the development of STEAM Education. Educational policies can assist educators in adopting STEAM Education in school in establishing operating processes, quality standards for teaching and learning, and setting accountability and expectations. The absence of policies would stop the schools from functioning according to the structure to meet students' educational needs. Thus, policies are critical to a school's performance and can give various benefits if they are well-planned, well-designed, well-written, well-coordinated, and well-implemented because they respond to the field's actual happenings.

The participants are concerned about the incompleteness of the curriculum due to the lack of some disciplines or subjects that they believe should be integrated or added to the current curriculum. The interviewed participants thought that character education subjects, arts, and other science-related courses are missing in the present curriculum since STEM is overly focused on content and very technical and mechanical in nature. Further, the participants argued that the STEM curriculum is centralized on the growth of the left-brain of students which is not aligned to the overall goal of our education system which is to produce holistically developed students. They thought that arts integration in the STEM curriculum would make it better. Arts disciplines such as painting, music, theatre, dance, among many others, have been shown to improve students' learning, attention, and cognition (Posner & Patoine, 2010; Zhbanova, 2017).

Additionally, art increases learning strategies and global competencies (Sinay et al., 2018). In STEAM education, arts is integrated since the subject fosters creativity among students. Creativity is at the core of STEAM education since it is believed to be at



Philippine Normal University National Center for Teacher Education

the heart of science and art. As it instills workforce development, cultural relevance, and social-emotional learning, arts combined with real-world experiences can serve as an impetus for the STEAM curriculum (Tenaglia, 2017).

It is also evident that some skills are wanted by the participants for students to attain. These skills include being innovative, creative, critical, and reflective. They can make STEM students more holistically developed. Innovative skills will help learners to explore, think outside the box, and uncover something new. Creative skills improve one's problem-solving skills, enhance one's expression without hindrance, reinforce innovativeness, and promote lifelong learning. Meanwhile, being a critical thinker encourages curiosity, promotes creativity, and fosters independent skills. Lastly, reflective skills develop self-awareness, improve self-confidence, boost engagement, and transform one's weakness into a strength. With these four skills, participants claimed that students would be competent and productive citizens of the country. This objective is in consonance with the goals intended by STEAM Education. STEAM Education gives students opportunities to work with each other with as little interference coming from the teacher. With the teachers' minimal interaction, students learn even from mistakes. Thus, STEAM Education makes sure students gain something from the mistake and encourages them self-direction, not just to feed them ideas and concepts but to let them seek answers for themselves. STEAM Education will help them explore more creative ways of finding answers.

STEAM Education provides a means for the students to exercise innovative thinking and creativity. Through this approach, students' thoughts are cultivated to foster



Philippine Normal University National Center for Teacher Education

the imagination of becoming a scientist or engineer. Moreover, studies showed that STEAM strategies intensify the students' enjoyment in learning and fosters longer learning retention (Brouillette & Graham, 2016; Rahmawati et al., 2018). In addition, STEAM Education enhances students' creativity and self-expression, boosts interest in the STEM field, cultivates the problem-solving skills of the students, improves convergent and divergent thinking skills, provides a trail for self-motivation and personal meaning-making, and enhances the 21st-century skills and Future Skills (Land, 2013; Madden et al., 2013; Perignat & Katz-Buonincontro, 2019; Psycharis, 2018; Watthananon, 2018).

The discussion on the curriculum cannot be completed without the parents and institution support and community partnership. Parents and community, as well as the institution itself, are partners in education. The involvement of them as stakeholders creates a fluidity of educational instruments for practical and conducive management. There are known benefits regarding parents and community participation, such as cooperation in the aspects of curricula and education, good education commitment results, decision-making, and internalization of the school's connection to the people who can outspread those walls into the student's environment. Thus, there is no reason to exclude the stakeholders' engagement in the implementation of the curriculum because teachers, administrators, and other professional experts cannot replace the element of educational support by engaging internal and external stakeholders.



Philippine Normal University National Center for Teacher Education

The considerations discussed are taken. Hence an emergent framework was conceptualized, designed, and developed for the implementation of STEAM Education in the country.

The Emergent Grounded Theory: STEAM Education Framework

All the codes generated in the interview were related and integrated with each other using the Strauss-Corbin techniques of developing a story and creating diagrams (sketching). Early conception was promoted, and the resulting framework was visualized through many rounds of sketching during the coding process. The data visualization and sketches evolved as the interview progressed with the participants using theoretical sampling. Further, iterations of the drawings were made during the coding process as the categories evolved, as shown in Figures 36, 37, and 38. An extensive amount of work was put into developing improved infographics that would help explain the findings. A framework was developed with the explanation of the relationship of generated themes to STEAM Education in the preceding section and with the refinement of the sketching process.

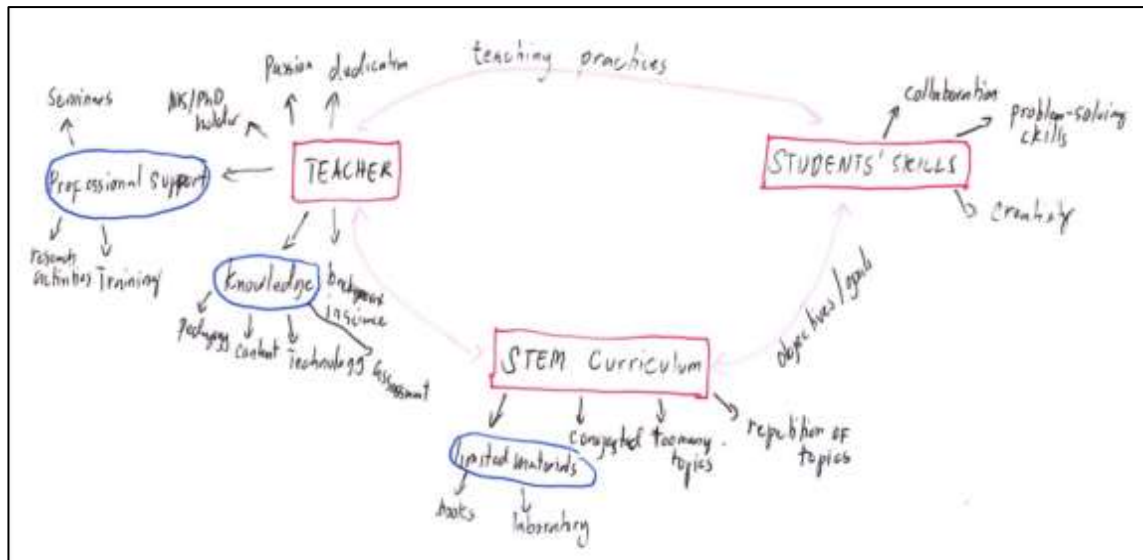


Figure 36. The researchers' sketching and diagramming at the initial interview.

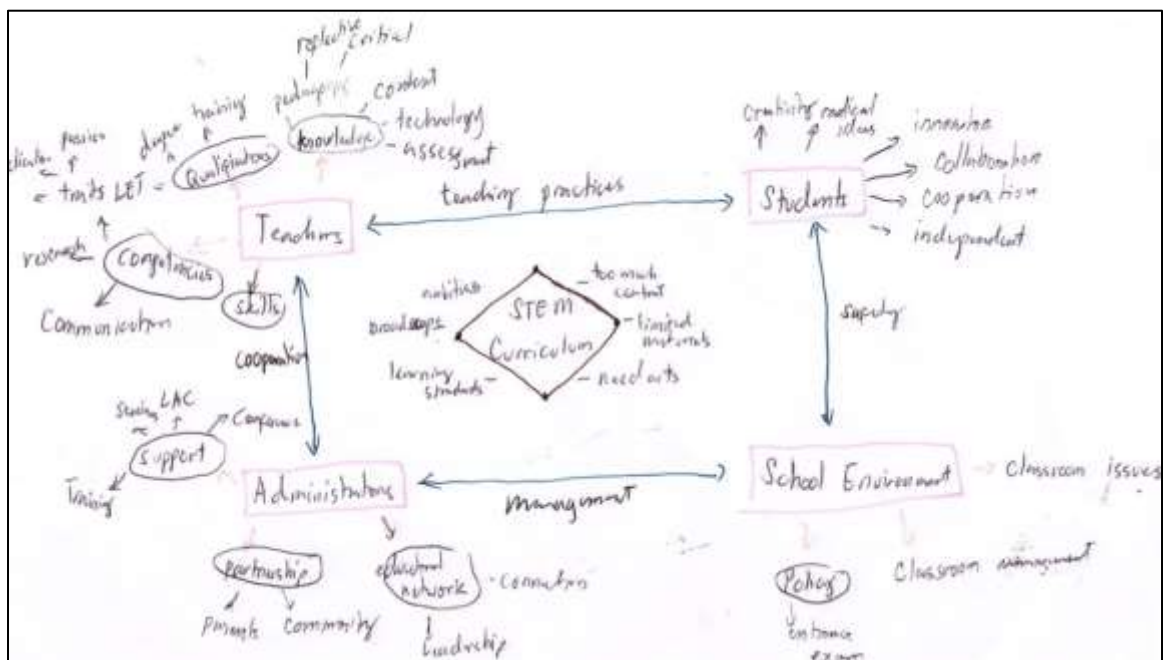


Figure 37. The sketch of the grounded theory at the 13th interview.

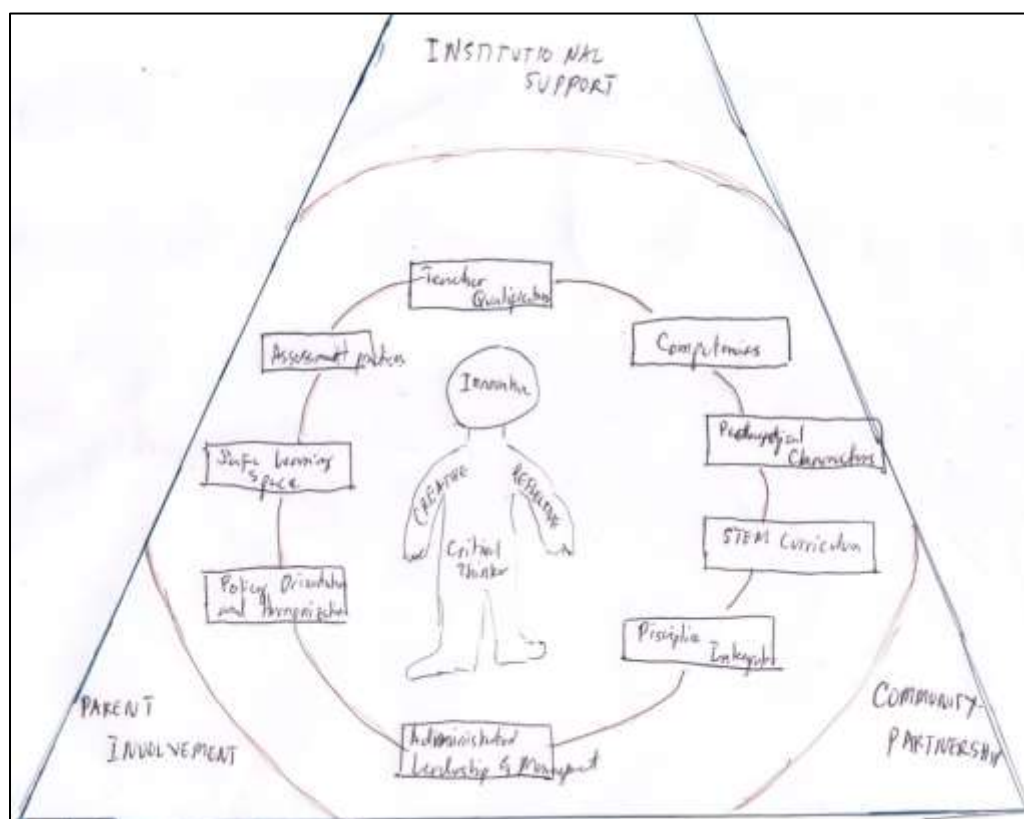


Figure 38. The sketch of the selective codes at the end of all interviews and before the refinement of codes.

Figure 39 shows the emerging STEAM Education framework for SHS STEM Strand. The framework illustrates the quality themes and areas needed for a successful STEAM Education implementation at the senior high school level. The various themes or standards were sourced out from the semi-structured interviews of 11 SHS STEM Strand teachers and 11 administrators in Nueva Ecija using a grounded theory approach. The interview lasted 58 minutes to 1 hour and 48 minutes for each participant. The emerging framework is envisioned to provide a concrete picture of what is needed and critical areas to improve for STEAM Education to be implemented in the country. With this



framework, the implementation of STEAM education will be prepared, planned, and systematized leading to an organized delivery and management of this curriculum or approach in the country.

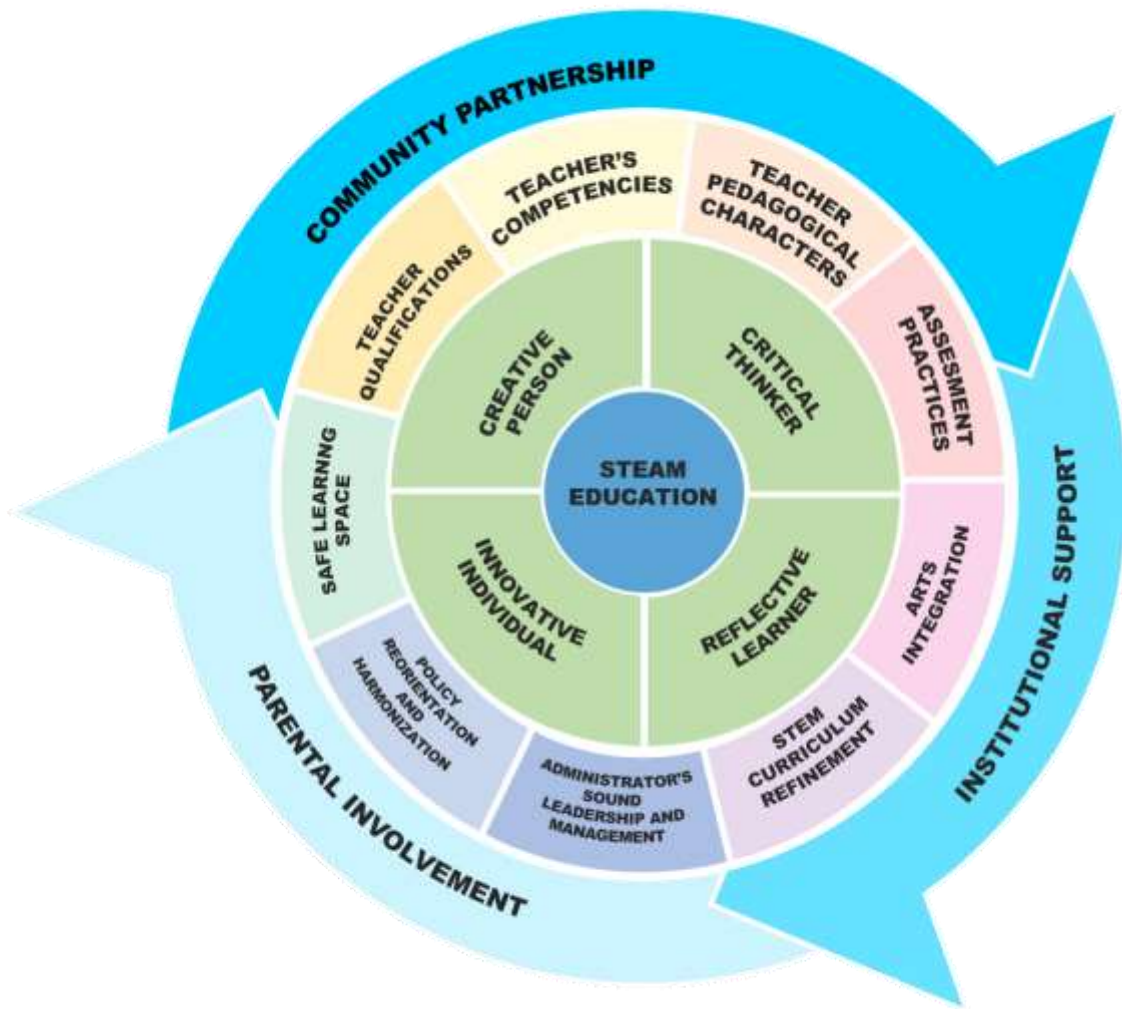


Figure 39. *The emergent STEAM Education Framework*

The framework is in a wheel-like diagram with a circular motion (cycle) in the outermost part of the figure. It consists of three inner circles and a cycle on the outside



Philippine Normal University National Center for Teacher Education

consisting of three arrows which are in a continuous motion emphasizing the outcomes and the standards needed for STEAM Education in the country. Surrounding the STEAM Education (innermost circle) is the end-product that teachers and administrators intend to produce: holistically developed SHS STEM students with 21st Century skills and Future skills. STEAM learning will be relevant and evocative that the 21st-century skills and future skills of the students will be honed strongly and productively to support Industry 4.0. Hence, these students are expected to be creative, innovative, critical thinkers, and reflective learners. STEAM education is an innovative way of teaching and learning, thus providing an inventive way to turn students into creative and well-rounded individuals. However, these goals will not be realized without the reform and strengthening of each standard as shown in the next inner circle. STEAM Education implementation will only be successful if there will be STEM curriculum refinement, arts integration, good assessment practices, eminent teacher pedagogical characters, improved teacher competencies, and good teacher qualification standards. In addition, safe learning space, policy reorientation and harmonization, as well as administrators' sound leadership and effective management, are expected to contribute to the realization of effective implementation of STEAM Education. Yet, this will be counter-productive if external stakeholders such as parents, the community, and the school itself will not support the curriculum. Stakeholders shape the curriculum. The involvement of the said stakeholders creates a better flow of educational mechanisms for management and implementation which is conducive and practical. Thus, the cycle in the framework depicts the



Philippine Normal University National Center for Teacher Education

contribution of this continuous and important support and partnership in STEAM Education.

The circular depiction of the framework underlies that the circle is symbolism for perfection, completion, wholeness, and vitality. Circle embraces the never-ending process of the variables shaping the STEAM Education in the country. Circle also represents evolution and growth as a way of transformation complementing the researcher's main objective to revolutionize STEM Education in the country into a relevant and contextualized STEAM Education.

For the color aspect, the researcher uses cool colors for each part in the framework. Cool colors include blue, lavender, yellow, and green colors. The researcher uses blue color for the cycle depicted in arrows to show a harmonious relationship with the needed support or partnership. The blue color is also often associated with responsibility which is the main consideration of the stakeholders as they are also responsible for the progress of students. The different hues of blue accounted for the uniqueness of the support needed and given by the school, parents, and the community. The different cool colors ranging from lavender to light yellow of the second outer circle symbolize nurturing like the nurturing effect of each element in the realization of STEAM Education. Meanwhile, the green color that accentuates productive citizens' characteristics (*creative persons, innovative individuals, critical thinkers, and reflective learners*) signifies growth and abundance. These encircle the STEAM Education colored in another shade of blue which signifies reliability and strength as STEAM Education



Philippine Normal University National Center for Teacher Education

hopes to provide more meaningful and effective means of connecting and engaging learners in science.

Standards of the Framework

The central part of this framework is the spectrum of salient standards or needs sourced out and accented on responses of the interviewed STEM teachers and administrators, namely teacher's qualifications, teacher competencies, teacher pedagogical characteristics, STEM curriculum refinement, discipline-integration, assessment practices, policy reorientation and harmonization, safe learning space, and administrator' leadership and management. These standards are the areas that are hoping to be improved or obtained for the effective implementation of STEAM Education in the country.

1. *Teachers' qualifications* – A salient element pertaining to the minimum qualification standards a STEAM teacher must have to teach in senior high school with STEM Strand which includes: having specialization aligned with the subjects in the STEM Strand, possessing advanced degree such as master's (MS/MA) and doctor's degree (PhD), having specialized training on the subject which one teaches, passing of Board of Licensure Examination for Professional Teachers (BLEPT), and having sufficient teaching experience. These qualifications are expected to improve and deepen the learners' potential and abilities.



Philippine Normal University National Center for Teacher Education

2. *Teachers' competencies* – This refers to the knowledge, experience, and skills a teacher possesses as one of the driving mechanisms of a sustainable educational system. Six teacher competencies are deemed necessary in the STEAM Education to wit: subject-matter competency, lifelong learning competency, technological competency, research competency, communication competency, and emotional and self-attributed competencies.
3. *Teacher pedagogical characters* – This pertains to the ideology, system of thinking, and sets of behavior and attitudes of a teacher which are demonstrated and manifested mainly on their overall pedagogical strategies and teaching practices. Three sets of characters, namely Communicating, Engaging, and Transforming Teachers, have been identified based on the teacher's pedagogical techniques in their teaching. Communicating Teacher employs interactive pedagogy while Engaging Teacher utilizes collaborative or cooperative pedagogy. Meanwhile, Transforming Teacher uses creative, reflective, or critical pedagogy. Each character shows a unique relationship with each other wherein Communicating Teacher is subordinating to the Engaging Teacher and these two characters are subordinating or under the principal character of Transforming Teacher.
4. *STEM Curriculum refinement* – An element that presents the features of the STEM Curriculum that requires enhancement and modification as an aid to the implementation of STEAM Education in the country at the senior high school level. The STEM curriculum now has good features but still needs



Philippine Normal University National Center for Teacher Education

improvement in certain areas. As reiterated by the participants, they described the curriculum as *comprehensive yet congested, work-oriented yet very idealistic, and well-designed yet problematic*.

5. *Arts integration* – This is a salient feature that is mandatory to achieve STEAM Education at the high school level in the country. Inclusion of Arts in the STEM subjects will assure the holistic well-being of students in terms of creativity and intelligence.
6. *Assessment Practices* – As assessment is the prime instrument of teachers to effectively determine the progress of the student's learning, performance, and skills, it can be inferred that teachers' assessment practices are integral parts of the teaching-learning process in STEAM Education. The strategies that teachers employ in the formative and summative assessment and their collaboration with their colleagues and administrators could allow them to make better decisions on instructional strategies that they can implement to blend on the students' abilities.
7. *Policy reorientation and harmonization* – Certain policies in the STEM Curriculum need to be reoriented, changed, included or harmonized in order to streamline the implementation of STEAM Education. Concerns such as entrance examination, non-board passer teachers, STEM teachers with many or mismatched subjects, STEM students switching to different strand and non-science courses, and the harmonization of scheduling of STEM subjects need to be addressed with new or modified policies.



Philippine Normal University National Center for Teacher Education

8. *Safe learning space* – This includes the environmental factors, physical environments such as overall structure, equipment, and facilities of the school, classroom climate and management, and teacher's affective traits which deal with the appeal to emotions and the heart of education. Safe learning space provides a secured environment that includes diversity and inclusivity, protection from violence both within and outside the school, and appropriate pedagogy and curriculum. With this, quality STEAM Education may be provided.
9. *Administrator leadership and management* – This pertains to how an administrator in the senior high school level manages the STEM Strand as being stewards, managers, and to their teachers. As transformative leaders, they provide managerial leadership, instructional leadership, strategic thinking innovation, stakeholder engagement, and personal excellence which will aid the attainment of STEAM education.

Using these standards, the framework is envisioned to lay a foundation and promote STEAM Education/Approach as an integral educational approach that will be relevant to the Philippine Basic Science Education which will contribute to the continuous improvement of science and engineering education in the tertiary or college level.



III. Validated Framework, Standards and Indicators, and Training Design

The foci of this section are the validation results and the generated outputs in relation to the validated STEAM Education Framework. This section is divided into four areas anchored to the study's third research question: "What modifications are needed to improve the developed framework based on validation processes: (a) What inputs may be derived from experts? (b) What are the elements and processes of a training design that can be derived from the developed framework? (c) What are the indicators and standards for STEAM Education in SHS that can be derived from the framework?"

The first area presents the validation result of the panel of experts on the emergent framework. The modifications made in the emergent framework were also explained in this part. The second area supplies the Quigley of the validated grounded theory. The third area establishes the training design derived from the validated framework. Lastly, the fourth area provides the validation result of the mentioned outputs.

Validation result of the emergent grounded theory

To validate the emergent framework, a Delphi technique with a five-panel expert was utilized. A PhD STEAM Education degree holder who is also a professor in Nepal, a PhD Science Education degree holder who is also an SHS STEM Strand science teacher, two (2) PhD in Curriculum and Instruction degree holders, and a PhD Science Education degree holder who is also an Education Program Supervisor (EPS) - Science in Nueva Ecija constituted the panel of expert-validators. Three rounds of validation in the Delphi



Philippine Normal University National Center for Teacher Education

technique were conducted before a consensus of acceptance of the framework was attained.

The first round of validation revealed that the validators found the emergent STEAM Education framework to be comprehensive, complete, impressive, and holistic. One of the validators claimed that the framework captures the desired outcome of what a STEAM Education should achieve and each of the principles, features, and components of the framework is aligned with STEAM Education. Another validator commented that the developed framework reflects the context of the future STEAM Education in the country. When asked if the developed framework could be applied in a real-world setting, all the validators agreed. They believe that the framework is doable and practical and the crafted standards are really grounded on what is happening in the secondary education of the Philippines. Moreover, they claimed that the developed framework could be used as a guiding framework for the STEAM Education rollout as each of its components are the targeted goals to be achieved by STEAM and could be applied in the Philippine SHS setting if supported by policies, training programs, and resources. Garira (2020) stated that an education framework could serve its intent or purpose if its components and elements address the grassroots process or approach of the topic or theory.

However, they still suggested some modifications for the improvement of the framework. One of the validators commented that there is a redundancy in the framework's standards and can be improved if put under the same umbrella. Also, one of the validators suggested that the standards could be categorized by each person involved, such as teachers and administrators, to clarify who is responsible for each standard. In



Philippine Normal University National Center for Teacher Education

addition, a validator proposed to improve the color continuity of the standards and the components of the framework be rearranged so that each of them is aligned to one another. Furthermore, another validator suggested making the color of the framework more vibrant to reflect creativity which is the core of STEAM education. This suggestion is aligned with the study of Chang, Xu, and Watt (2018) that color enhances learning, captures attention, and influences mood in educational settings. Table 18 summarizes the suggestions and comments of the validators and the actions done by the researchers in each proposal.

Table 18. Summary of suggestions of validators for the developed framework and the researcher's action

Validation Question	Remarks	Revisions Made
If you were to design the framework, what other principles, features, or components would you include?	This framework is quite impressive and holistic. However, I just noticed that it focuses on all the elements external to the learner (e.g. teachers, environment, admin, policies). This gives the impression that the outcome that we envision of STEAM learners is all about what is going to be done by the education sector TO them, not with them. (Validator 1)	The researcher explained to the validator that the developed framework is more of an implementation, thus, teachers, administrators, among others are the highlight in this framework.
	In the current DepEd Framework, we have STEM without Arts because it belongs to Arts and Design Strand as an independent track. That is why the migration of Arts in STEAM seems	A training design from the framework will be crafted.



Philippine Normal University
National Center for Teacher Education

	challenging. Most science teachers have no background concerning arts. Therefore, training & support for teachers can be one of the main elements in the framework. (Validator 4)	
What area(s)/component(s) of the framework do you feel that demand or need the most revisions?	I hope a standard for learners will also be incorporated so that STEAM education will be more of a learning engagement WITH them, rather than actions or policies applied TO them. (Validator 1)	The description for learners to become productive citizens was detailed in the framework
	Parental involvement and challenges that can be met in assessment practices. (Validator 2)	The description of the standards for assessment practices was elaborately written and in the discussion on the partnership and support.
	I think there is a redundancy wherein I read that it's all about standards for teachers such as teacher pedagogical characters, teacher competencies, etc. I believe it can be revised that these standards will be under one umbrella. (Validator 3)	The framework was modified such that standards for teachers were under one umbrella.
Do you have any suggestions or comments for the improvement of the framework? Please provide the details.	It would also help to provide more specific description of what we envision on the art integration. (Validator 1)	The discussion of arts integration was made more specific on what the teachers and administrators were expected to do in this standard.
	Will there be a possibility that	The components are re-



Philippine Normal University National Center for Teacher Education

	color continuity be made starting from the outside components to the inside? Can the components be re-arranged in such a way that each of them be aligned from one another? (Validator 2)	arranged as suggested. Color continuity for each component was also made.
	Since the outer circle represents the stakeholders such as parents and community, I suggest that the standards be categorized in each person involved, such as teacher and administrator, so that it is clear who is responsible for each standard. (Validator 3)	The framework was revised such that the standards were under specific stakeholders such as teachers, administrators, and policy and curriculum makers.
	I think the color of the framework should be made more vibrant to complement creativity, the focus of STEAM Education. (Validator 5)	The color of each standard was made more vibrant, as suggested.

All the comments of validators were noted and some of the suggestions were incorporated with the approval of the researcher's adviser. A framework incorporating the expert-validators comments and suggestions was crafted. For the second round of validation, another validation tool was given to the experts (Appendix AH). This tool involves a questionnaire composed of 24 statements answerable in a five-point Likert scale to express their agreement or disagreement. The statements are divided into three areas of validation: seven statements for content and organization, 11 statements for relevance and usability, and six statements for aesthetic and presentation. The comments of the validators from the first Delphi round and the questionnaires of Kissick (2015) and



Philippine Normal University National Center for Teacher Education

Naradi et al. (2013) served as the basis of items in the questionnaire for the second Delphi round. The validation tool (Appendix AH), the resultant framework from the first Delphi round (Appendix AI), and the summary of the changes and revisions (Appendix AJ) were given to the panel of experts. Tables 19, 20, and 21 show the result of their evaluation in each area of validation.

Table 19 reveals that the validators strongly agree that the framework is excellent in terms of content and organization, with a mean score of 4.83. They strongly agree with all of the statements as shown in the table. They approve that each component of the framework is well described, clearly discussed, and the framework is easy to follow and understand, comprehensive, and adds to the body of knowledge, among others.

Table 19. The result of validation in terms of content and organization of the framework.

Statement	Mean Score	Interpretation
Each component of the framework is well described.	4.40	Strongly agree
The principles and elements of the framework are clearly discussed.	4.60	Strongly agree
The framework is easy to follow and understand.	5.00	Strongly agree
The framework adds to the body of knowledge.	5.00	Strongly agree
The framework is grounded on the situation of the SHS science curriculum in the country.	5.00	Strongly agree
The framework captures the desired outcome of what a STEAM Education should achieve.	4.80	Strongly agree
The framework is comprehensive.	5.00	Strongly agree
OVERALL MEAN	4.83	



Philippine Normal University National Center for Teacher Education

Also, the validators strongly agree that the framework is relevant and usable with a total mean score of 4.93 (Table 20). They believed that the framework is relevant to the science curriculum of the country, to the current conditions and trends, and to the development of STEAM education in senior high school. Regarding usability, they held that DepEd and other individuals could efficiently utilize the framework, feasible to implement, and adapt for different contexts or subjects.

Table 20. The result of validation in terms of relevance and usability of the framework.

Statement	Mean Score	Interpretation
The framework can be used as a guiding framework for the STEAM Education rollout.	5.00	Strongly agree
The framework is relevant to the development of STEAM Education in Senior High School.	5.00	Strongly agree
The framework reflects the context of the future STEAM Education in the country.	5.00	Strongly agree
The Department of Education and other interested individuals can easily use the framework.	5.00	Strongly agree
The framework can be utilized in a science classroom.	5.00	Strongly agree
The framework is feasible to be implemented.	5.00	Strongly agree
The framework can possibly be adapted for different contexts or subjects.	4.60	Strongly agree
The framework is relevant to the Science curriculum.	5.00	Strongly agree
The framework is relevant to the current conditions and trends.	5.00	Strongly agree
The salient features of the framework are unique and relevant.	4.60	Strongly agree
The framework is doable and practical.	5.00	Strongly agree
OVERALL MEAN	4.93	



Philippine Normal University National Center for Teacher Education

On the other hand, the third area of validation, the aesthetics and presentation, revealed that the validators strongly agree on most of the items (Table 21). However, there are still components that could be improved. They believe that the framework is visually appealing, logically sequenced and presented, and understandable. But, three of the validators neither agree nor disagree that the framework and its elements are clearly illustrated. Shala (2018) underscores the importance of a well-defined and well-illustrated framework as its intended audience will efficiently utilize and understand its purpose. When the researcher reviewed the remarks box for this item, the validators suggested that the standards such as administrators' sound leadership and effective management and policy orientation and harmonization be divided in the framework's presentation.

Table 21. The result of validation in terms of aesthetics and presentation of the framework.

Statement	Mean Score	Interpretation
The framework is visually appealing.	4.80	Strongly agree
The principles and components are logically presented.	5.00	Strongly agree
The framework and its elements are clearly illustrated.	3.60	Agree
The framework is logically sequenced.	5.00	Strongly agree
The presentation of the framework is understandable.	5.00	Strongly agree
The language used is clear and easy to understand.	5.00	Strongly agree
OVERALL MEAN	4.73	



Philippine Normal University National Center for Teacher Education

Thus, another framework revision was done since a consensus of acceptance of the framework was not attained. The data obtained from the "remark" box of the item where agreement is not reached were used to revise the framework. On the third Delphi round, the item received a mean score of 4.60, thus, the validators now strongly agree that the framework and its elements are clearly illustrated. Therefore, a consensus of acceptance of the framework was attained in the third Delphi round. The validated framework and its description are presented in the next section.

The validated grounded theory

Figure 40 shows the validated STEAM Education framework for SHS STEM Strand after the three rounds of the Delphi technique. The framework illustrates the quality themes and areas needed for a successful STEAM Education implementation at the senior high school level. The various themes or standards were sourced out from the semi-structured interviews of 11 SHS STEM Strand teachers and 11 administrators in Nueva Ecija using a grounded theory approach. The interview lasted 58 minutes to 1 hour and 48 minutes for each participant. The validated framework is envisioned to provide a concrete picture of what is needed and critical areas to improve for STEAM Education to be implemented in the country. With this developed framework, it is expected that the implementation of STEAM education will be prepared, planned, and systematized leading to an organized delivery and management of this curriculum or approach in the country.

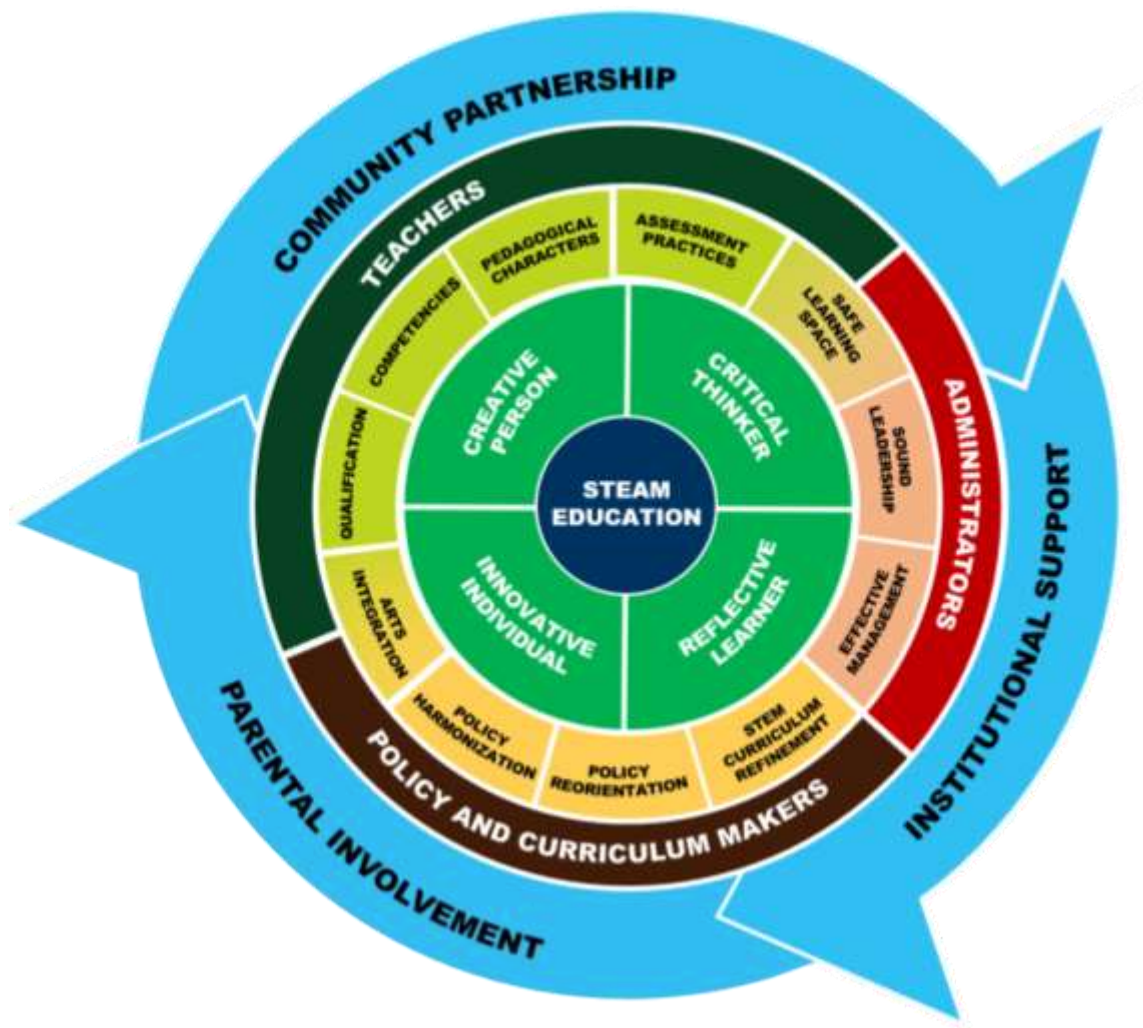


Figure 40. *The validated STEAM Education Framework*

The framework is in a wheel-like diagram with a circular motion (cycle) in the outermost part of the figure. It consists of four inner circles and a cycle on the outside consisting of three arrows which are in a continuous motion emphasizing the outcomes and the standards needed for STEAM Education in the country. Surrounding the STEAM Education (innermost circle) is the end-product that teachers and administrators intend to



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produce: holistically developed SHS STEM students with 21st Century skills and future skills. STEAM learning will be relevant and evocative that the 21st-century skills and future skills of the students will be honed strongly and productively to support Industry 4.0. Hence, these students are expected to be creative, innovative, critical thinkers, and reflective learners. STEAM education is an innovative way of teaching and learning, thus providing an inventive way to turn students into creative and well-rounded individuals. However, these goals will not be realized without the reform and strengthening of each standard as shown in the next inner circle. STEAM Education implementation will only be successful if there will be STEM curriculum refinement, arts integration, good assessment practices, eminent teacher pedagogical characters, improved teacher competencies, and good teacher qualification standards. In addition, safe learning space, policy reorientation and harmonization, as well as administrators' sound leadership and effective management, are expected to contribute to the realization of effective implementation of STEAM Education. Yet, this will be counter-productive if external stakeholders such as parents, the community, and the school itself will not support the curriculum. Stakeholders shape the curriculum. The involvement of the said stakeholders creates a better flow of educational mechanisms for management and implementation which is conducive and practical. Thus, the cycle in the framework depicts the contribution of this continuous and important support and partnership in STEAM Education.



Philippine Normal University National Center for Teacher Education

The emphasis on the different roles of stakeholders in the validated framework at the outer circle highlights their importance of implementing STEAM education in the country. The curriculum is a cooperative venture among teachers, administrators, curriculum experts, policy makers, learners, parents, and the community (Janmaat, McCowan, & Rao, 2016). Teachers are known to be the curriculum makers and the architect of the curriculum. Meanwhile, overseeing curriculum implementation and improving the school's physical plant and facilities are major responsibilities of school administrators. They are in charge of admitting students, recruiting and selecting new teachers, as well as, procuring the tools and equipment required for effective teaching and learning. Policy and curriculum makers have a significant role in the education system as they are the decision-thinking people of the government in the development of policies and curriculum benefitting the students. Parents and the community provide essential support to the school and sustenance of a healthy school environment. In developing, executing, and evaluating schools' education programs, stakeholders' input and relationships with other stakeholders are critical. Thus, a collaborative effort between the internal and external stakeholders will ensure the effectiveness of the STEAM education curriculum.

The circular depiction of the framework underlies that the circle is symbolism for perfection, completion, wholeness, and vitality (Putnam, 2021). Circle has no end and beginning (Chwalkowski, 2016) depicting the never-ending process of the variables shaping the STEAM Education in the country. Circle also represents evolution and growth as a way of transformation (Putnam, 2021; Zhu & Yue, 2018) complementing the



Philippine Normal University National Center for Teacher Education

researcher's main objective to revolutionize STEM education in the country into a relevant and contextualized STEAM Education.

For the color aspect, the researcher uses cool colors for each part in the framework. Cool colors include blue, green, brown, and light orange (Kurt & Osueke, 2014). The researcher uses blue color for the cycle depicted in three arrows to show a harmonious relationship with the needed support or partnership. The blue color is also often associated with responsibility (Cerrato, 2012) which is the main consideration of the stakeholders as they are also responsible for the progress of students. The three arrows accounted for the uniqueness of the support needed and given by the school, parents, and the community. The different cool colors ranging from light green, light brown, and light orange of the second outer circle symbolize nurturing (Elliot & Maier, 2014; Kurt & Osueke, 2014) like the nurturing effect of each element in the realization of STEAM Education. The dark green color for teachers signifies creativity and vitality (Fogelstrom, 2013) which shows how a teacher must teach in a STEAM classroom.

On the other hand, the dark orange color of the administrator symbolizes passion, wisdom, and action (Fogelstrom, 2013) which is likened to how the administrators supervise, manage, and lead the school. Further, the brown color for policy and curriculum makers depicts security, dependability, and resilience reflecting how policy and curriculum makers shape the country's curriculum implementation and development (Cerrato, 2012). Meanwhile, the moss green color accentuates productive citizens' characteristics (*creative persons, innovative individuals, critical thinkers, and reflective learners*) that signify growth and abundance (Cerrato, 2012; Fogelstrom, 2013). These



Philippine Normal University National Center for Teacher Education

encircle the STEAM Education colored in another shade of blue which symbolizes reliability and strength (Won & Westland, 2017) as STEAM education hopes to provide more meaningful and effective means of connecting and engaging learners in science.

Standards of the Framework

The central part of this framework is the spectrum of salient standards or needs sourced out and accented on responses of the interviewed STEM teachers and administrators, namely teacher's qualifications, teacher competencies, teacher pedagogical characteristics, STEM curriculum refinement, arts integration, assessment practices, policy reorientation and harmonization, safe learning space, and administrator's leadership and management. These standards are the areas hoping to be improved or obtained for the effective implementation of STEAM Education in the country. They were categorized according to the persons who were responsible for each standard.

Teachers

Standard 1. Qualifications – A salient element pertaining to the minimum qualification standards a STEAM teacher must have to teach in senior high school with STEM Strand which includes: having specialization aligned with the subjects in the STEM Strand, possessing advanced degree such as master's (MS/MA) and doctor's degree (PhD), having specialized training on the subject which one teaches, passing of Board of Licensure Examination for Professional Teachers (BLEPT), and having sufficient teaching experience. These



Philippine Normal University National Center for Teacher Education

qualifications are expected to improve and deepen the learners' potential and abilities.

Standard 2. Competencies – This refers to the knowledge, experience, and skills a teacher possesses as one of the driving mechanisms of a sustainable educational system. Six teacher competencies are deemed necessary in the STEAM Education to wit: subject-matter competency, lifelong learning competency, technological competency, research competency, communication competency, and emotional and self-attributed competencies.

Standard 3. Pedagogical characters – This pertains to the ideology, system of thinking, and sets of behavior and attitudes of a teacher which are demonstrated and manifested mainly on their overall pedagogical strategies and teaching practices. Three sets of characters, namely Communicating, Engaging, and Transforming Teachers, have been identified based on the teacher's pedagogical techniques in their teaching. Communicating Teacher employs interactive pedagogy while Engaging Teacher utilizes collaborative or cooperative pedagogy. Meanwhile, Transforming Teacher uses creative, reflective, or critical pedagogy. Each character shows a unique relationship with each other wherein Communicating Teacher is subordinating to the Engaging Teacher and these two characters are subordinating or under the principal character of Transforming Teacher.

Standard 4. Assessment Practices – As assessment is the prime instrument of teachers to effectively determine the progress of the student's learning, performance, and



Philippine Normal University National Center for Teacher Education

skills, it can be inferred that teachers' assessment practices are integral parts of the teaching-learning process in STEAM Education. The strategies that teachers employ in the formative and summative assessment and their collaboration with their colleagues and administrators could allow them to make better decisions on instructional strategies that they can implement to blend on the students' abilities.

Administrators

Standard 5. Administrator leadership and management – This pertains to how an administrator at the senior high school level manages the STEM Strand as being stewards, managers, and to their teachers. As transformative leaders, they provide managerial leadership, instructional leadership, strategic thinking innovation, stakeholder engagement, and personal excellence which will aid the attainment of STEAM education.

Policy and curriculum makers

Standard 6. STEM Curriculum refinement – An element that presents the features of the STEM Curriculum that requires enhancement and modification as an aid to the implementation of STEAM Education in the country at the senior high school level. The STEM curriculum now has good features but still needs improvement in certain areas. As reiterated by the participants, they described the curriculum as *comprehensive yet congested, work-oriented yet very idealistic, and well-designed yet problematic*.



Philippine Normal University National Center for Teacher Education

Standard 7. Policy reorientation and harmonization – Certain policies in the STEM Curriculum need to be reoriented, changed, included, or harmonized in order to streamline the implementation of STEAM Education. Concerns such as entrance examination, non-board passer teachers, STEM teachers with many or mismatched subjects, STEM students switching to different strand and non-science courses, and the harmonization of scheduling of STEM subjects need to be addressed with new or modified policies.

Teachers and administrators

Standard 8. Safe learning space – This includes the environmental factors, physical environments such as overall structure, equipment, and facilities of the school, classroom climate and management, and teacher's affective traits which deal with the appeal to emotions and the heart of education. Safe learning space provides a secured environment that includes diversity and inclusivity, protection from violence both within and outside the school, and appropriate pedagogy and curriculum. With this, quality STEAM Education may be provided.

Teachers and curriculum makers

Standard 9. Arts integration – This is a salient feature that is mandatory to achieve STEAM Education at the high school level in the country. Inclusion of Arts in the STEM subjects will assure the holistic well-being of students in terms of creativity and intelligence.



Philippine Normal University National Center for Teacher Education

Using these standards, the framework is envisioned to lay a foundation and promote STEAM Education as an integral educational approach that will be relevant to the Philippine Basic Science Education which will contribute to the continuous improvement of science and engineering education in the tertiary or college level.

Set of Indicators

Standards and indicators define the criteria that must be met to attain higher levels of learning, child growth and development, and organizational success. Alqiawi and Ezzeldin (2015) state that standards provide a roadmap for achieving educational excellence and serve as a direction for continual improvement efforts.

Table 22 shows the standards and indicators sourced out from the framework which aimed to serve as a future quality assurance mechanism for the STEAM curriculum in the country. The indicators and standards aim to provide an objective way of measuring and demonstrating the success of the implementation of STEAM Education. Further, the indicators and standards will help DepEd plan, monitor, manage, and assess implemented STEAM Education at the SHS level. Table 22 also shows the proofs needed for verification.



Table 22. The standards and indicators sourced from the validated STEAM Education Framework for SHS STEM Strand

Standards	Indicators	Proofs needed for verification
Teacher Qualifications	The teachers have specialization aligned with the subject they teach	Diploma Transcript of Records (TOR) Professional Regulation Commission (PRC) License Copy of Certificate/s of Training attended Service Record
	The teachers possess advanced degrees such as master's or doctor's degrees relevant to the subject they teach	
	The teachers are passers of the Board of Licensure Examination for Professional Teachers (BLEPT)	
	The teachers have specialized training on the subject which they teach	
	The teachers have sufficient teaching experience	
Teacher Competencies	The teachers have a strong foundation and understanding of science, technology, engineering, arts, and mathematics (STEAM) subjects in terms of content knowledge.	Research proposal/ Research publication Copy of certificate of attendance or presentation in training, seminar, or workshop Copy of certification of active membership and ID Lesson exemplar with details on technology integration
	The teachers exhibit research skills by conducting researches related to STEAM teaching and learning.	
	The teachers continuously promote their lifelong learning competencies by attending and presenting in training, seminars, and workshops.	



Philippine Normal University
National Center for Teacher Education

	The teachers participate or are actively involved in professional organizations relevant to their field.	
	The teachers demonstrate technological skills in their teaching.	
Arts integration	Through a method that blends context and content, the teacher continually involves numerous disciplines such as arts, engineering, and mathematics.	Lesson Exemplar Morales et al. (2019) Classroom Observation Tool Instructional materials utilized during the lesson proper
	The teachers provide a curriculum that effortlessly combines knowledge from several subjects.	
	To satisfy the educational needs of distinct disciplines, the teachers frequently employ a range of instructional tactics and methodologies.	
	Frequently, the teachers explicitly combine various subjects.	
Teacher Pedagogical character	The teachers provide real-world tasks in which students can develop communication and teamwork skills by participating in a range of relevant learning exercises.	Lesson Exemplar Morales et al. (2019) Classroom Observation Tool Copy of student evaluation Instructional materials utilized during the lesson proper
	The teachers give instructions and demonstrate several tools and strategies that students can use while developing creative solutions.	



	The teacher constantly offers meaningful learning not only through cooperative and collaborative pedagogies but also through critical and reflective pedagogies.	
	The teachers frequently use various learning styles to encourage students to think of numerous solutions to a problem.	
Assessment Practices	Teachers have knowledge on using assessment tools and strategies appropriate in STEAM instruction and utilize them effectively.	Lesson Exemplar Morales et al. (2019) Classroom Observation Tool
	Teachers use the assessment data to proactively solve the challenges they face in the STEAM teaching-learning process.	Copy of the assessment and rubrics used Copy of student evaluation
	Teachers collaborate with each other in planning, implementing and monitoring of assessments.	Instructional materials utilized during the lesson proper
Curriculum refinement	The lessons intended to be taught in a subject can be finished for the school year.	Lesson exemplars
	Each subject has an intended teaching and learning guide.	Teaching and learning guides
	The school provides adequate materials and laboratory equipment.	Inventory of materials and laboratory equipment
	The school has sufficient laboratory rooms.	List of laboratory rooms in the school



<i>Safe Learning Space</i>	The teachers create a conducive classroom environment to facilitate STEAM learning.	Lesson exemplars Copy of student evaluation Copy of school records
	The school provides a secure environment that acknowledges diversity and inclusivity and is free from discrimination.	
	The teachers have defined and practiced classroom rules and procedures.	
	The teachers teach discipline among students.	
<i>Sound Administration and Effective Management</i>	The administrators support their teachers in terms of attendance in training, seminar, or workshop.	List of teachers who attended trainings Accomplishment report Copy of certificate of trainings/workshop/seminars attended
	The administrators provide well-defined decisions and create learning innovations.	
	The administrators establish educational networks and strengthen educational connections.	
	The administrators participate in a professional development program.	
	The administrators lead curriculum and development implementation and establish a learner-centered atmosphere.	
<i>Policy Orientation and Harmonization</i>	The school admits students based on grades and entrance examinations.	Result of entrance examination



	The teachers teach their subjects aligned with their specialization.	Copy of the workload of teachers
	The school offers subjects in the same schedule as other schools.	Copy of syllabus
	The teachers' workload is within the maximum allowable teaching load.	
<i>Involvement with stakeholders</i>	The school builds a partnership with the community, especially science institutions, for the work immersion of students.	Copy of memorandum of agreement
	The teachers and administrators engage and involve parents in student development.	Copy of memorandum of understanding
	The school collaborates with Local Government Units (LGUs) and Non-Government Organization (NGO).	Copy of the minutes of the PTA meeting Documentations

The validated framework along with its standards and indicators, are aligned to the Morales et al. (2020) Philippine STEAM Education Model. This model accounts for STEAM education's four variables: outcomes, drivers, institutional support, and processes. Like in the validated framework, the model establishes the outcomes for productive citizens, innovative STEAM learners, and 21st-century skills translated into the validated framework as creative persons, innovative individuals, critical thinkers, and reflective learners. In the model, teachers' knowledge and pedagogical characters, as well



Philippine Normal University National Center for Teacher Education

as institutional support, were also considered crucial factors and primary considerations in STEAM Education similar to the validated framework.

Quigley et al. (2020) STEAM conceptual model underscores the subjects integration, assessment alignment, problem-solving tasks, classroom environment, and learning context as guides for STEAM instruction (Figure 41). The model posits discipline integration as the connection or integration of multiple subject areas and ideas, while classroom environment refers to how teachers structure their classroom conducive for the teaching-learning process.

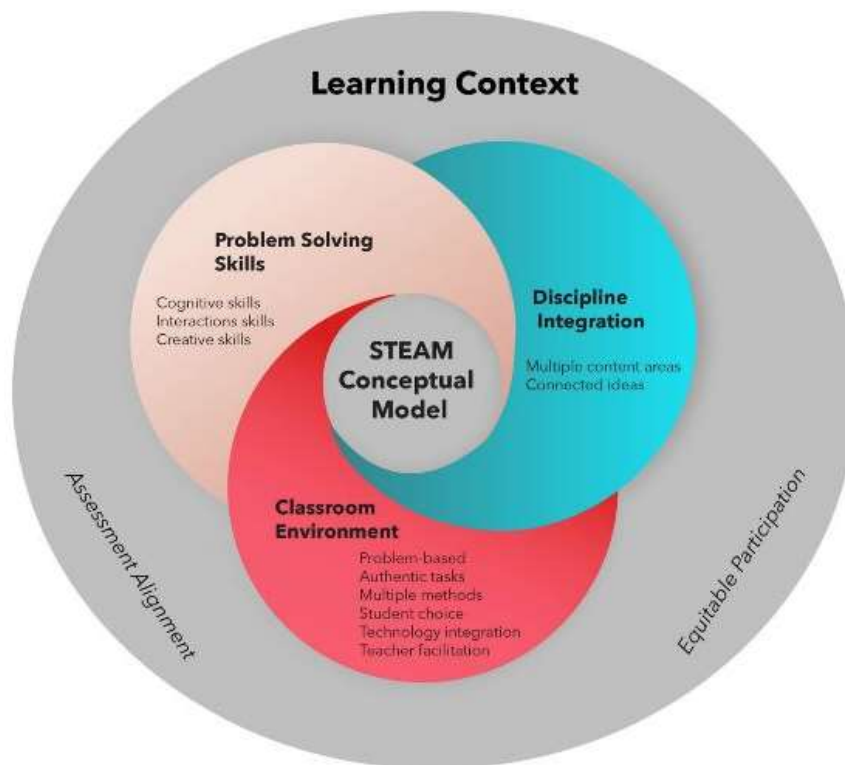


Figure 41. Quigley et al. (2020) STEAM Conceptual model



Philippine Normal University National Center for Teacher Education

Meanwhile, problem-solving skills define the methods and means on how teachers develop the student's creative, interactive, and cognitive skills through various teaching strategies. The same concepts also emerged in the validated framework with the standards on arts integration, safe learning space, and assessment practices.

In Taiwan, a STEAM Education Framework was proposed in implementing an interdisciplinary STEAM curriculum. In this framework, the proponents propose five strategies, namely Scaffolding, Tutoring, Engaging, Argumentation, and Modeling as curriculum activities in teaching through STEAM Education (Figure 42). *Scaffolding* will help the students complete and comprehend learning tasks while students may receive *tutoring* and be *engaged* in project-based learning. Throughout the teaching activities, teachers may use *argumentation* to highlight the impacts of science on the community. To unravel abstract concepts and motivate students in experimentation, *modeling* activities could be given (Lin & Tsai, 2021). The same concepts could be found in one of the salient standards in the validated framework. The Teachers Pedagogical Characters highlighted in the different pedagogical techniques employed by teachers such as interactive, cooperative, collaborative, creative, reflective, and critical pedagogies could be compared with the aforementioned five strategies.

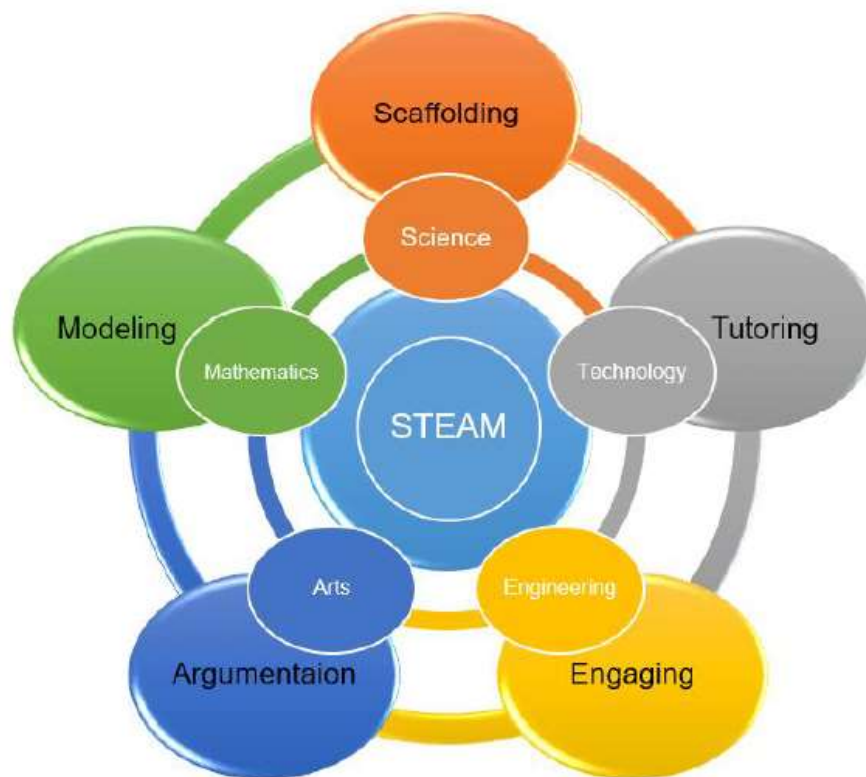


Figure 42. *Lin and Tsai (2021) STEAM education Framework*

In Korea, a Wheel framework of STEAM Education is being employed. In this framework, the traditional sciences contextualized in Korea are used to connect the Humanities and STEAM subjects. A multidisciplinary system was developed using STEAM subjects along with History, Geography, and Bibliography (Figure 43). Anchored with the wheel framework is how students are expected to produce innovative ideas and outputs. The framework emphasized products creation through knowledge convergence rather than a simple combination of knowledge from different fields. (Kim, 2016).

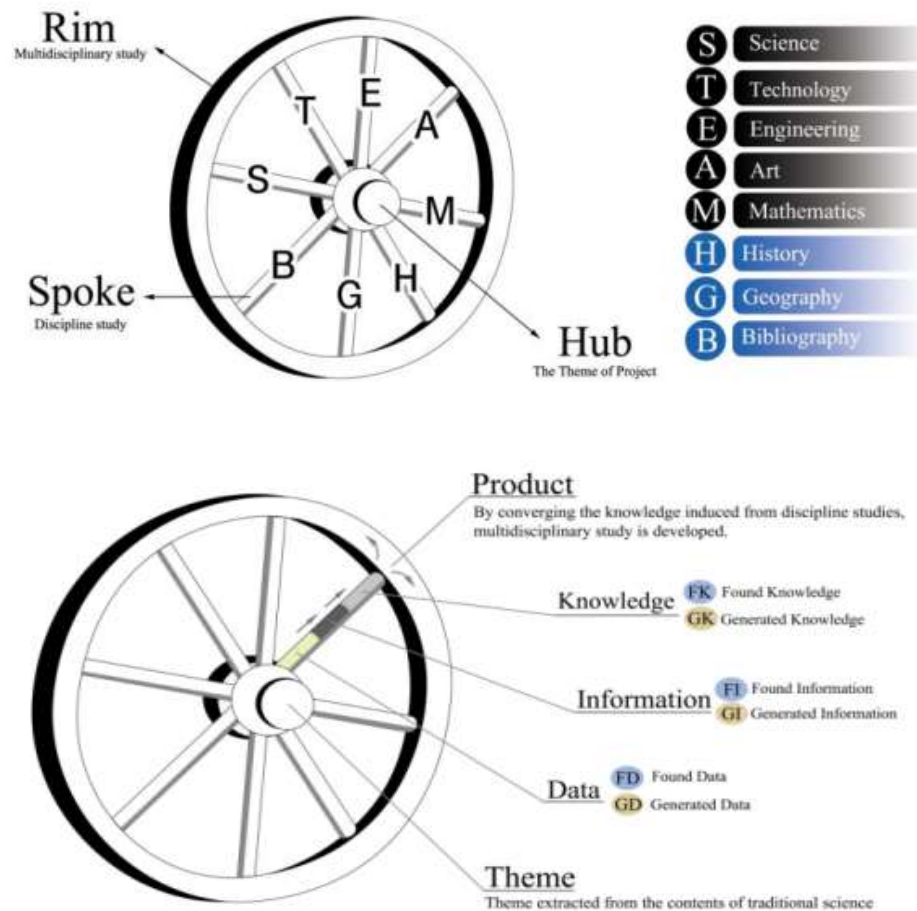


Figure 43. Kim (2016) *Wheel Framework of STEAM Education*

The mentioned STEAM Education frameworks developed from abroad focus more on the teaching strategies of the teachers and the disciplinarity of STEAM Education. In the validated framework of the researcher, the roles of different internal and external stakeholders such as teachers, administrators, students, parents, policy makers, and the community in the curriculum are emphasized. The framework highlights



Philippine Normal University National Center for Teacher Education

not only the mechanisms on teaching strategies of the teachers but also their needed qualifications, competencies, characters, and assessment practices. Similar to other frameworks, the validated framework also shows the end products to be attained, which are skilled students capable of becoming productive citizens of the country. Further, arts integration, which is the core of STEAM Education, is mostly present with the other frameworks.

On the other hand, the validated framework's set of indicators and standards is also aligned to the seven domains and 37 strands of the Philippine Professional Standards for Teachers (PPST). These domains such as content knowledge and pedagogy, learning environment, diversity of learners, curriculum and planning, assessment and reporting, community linkages and professional engagement, and personal growth and professional development, are reflected in the crafted standards and indicators.

The crafted standards and indicators, along with the proceeding section, training design are the suggested operationalization of the developed STEAM Education framework in the field.

Training Design

After validating the framework, a training design was developed in consonance with the validated STEAM Education Framework.

Teacher Professional Development Program

To achieve the quality STEAM Education we need, science teachers should be provided with the knowledge and skills in STEAM Education. To do such, teachers must



Philippine Normal University National Center for Teacher Education

adhere to professional development. Teacher quality has been proven to be enhanced through professional development programs. Teachers must be educated and harnessed continuously to become lifelong learners to promote quality education (Bicaj & Treska, 2014). This need is in line with the UNESCO Sustainable Development Goal No. 4, Quality Education, which states that one of the reasons for the lack of quality education is the insufficiency of trained teachers. Also, this aligns with the Philippine Development Plan 2017-2022 (Accelerating Human Capital Development) anchored on *Ambisyon Natin 2040*, which notes that there is so much indication of low-quality education in the Philippines, and one of the contributing factors is the lack of competent and trained teachers.

Teachers professional development program (TPDP) is defined as a combination of various activities for the teachers that promote lifelong learning. TPDP aimed to provide support to an effective role of the teacher. TPDP is so important that Mizelle (2010) contends that teachers who do not engage in training, seminars, and workshops do not improve their abilities and may contribute to difficulty in student learning. TPDP is vital in providing continuous learning of effective teaching methodologies, pedagogical tools and technology, and providing support to expertise or area of needs (Lee, 2013). Lee (2013) added that effective professional development must be sustained over time, grounded on research-based practices, content focused on curricular and teacher needs, and teacher collaboration must be sustained over time.

Hence, TPDP aims to address the needs of the teachers and students by serving as an avenue for expanding teachers' content and pedagogical knowledge, developing



Philippine Normal University National Center for Teacher Education

curriculum, and sharing the best practices for classroom instructions and management. It is also important because "it maintains and improves their performance of current practices and helps them cope with changes" (Khan & Begum, 2012, p. 363). This only shows the need of TPDP to fill in the gaps in the teachers' skills and expertise (Evers, van der Heijden, & Kreijns, 2016). Research stresses that for TPDP to be successful, TPDP must be sustainable and contain rigorous activities to improve the learning and teaching process (Badri, Alnuaimi, Mohaidat, Yang, & Al Rashedi, 2016; Richardson, 2003). In his paper, Desimone (2009) found five core features that could guide the developers of teacher training programs. These core features involved,

*"**content focus**—learning opportunities for teachers that focus on subject matter content and how students learn that content; **active learning**—can take a number of forms, including observing expert teachers, followed by interactive feedback and discussion, reviewing student work, or leading discussions; **coherence**—consistency with other learning experiences and with school, district, and state policy; **sufficient duration**—both the total number of hours and the span of time over which the hours take place; and **collective participation**—participation of teachers from the same school, grade, or department"*

These strategies may help construct knowledge, develop awareness, convert new knowledge into practice, and reflect profoundly on teaching and learning. Hence, the effectiveness of the TPDP may be ensured if the elements are present in training. Guskey's (2002) Model of Process of Teacher Change suggests that effective TPDP may result in three outcomes in succession. First, if the development and implementation of the TPDP are effective, it may result in a positive change in teachers' classroom practice.



Philippine Normal University National Center for Teacher Education

The changes in teacher's pedagogy may promote positive change in the students' learning outcomes, resulting in teachers' change in belief and attitude.

In their extensive literature survey about TPDP for 30 years (1987-2017), Darling-Hammond, Hyler, and Gardner (2017) recorded the seven shared elements or features of effective TPDP. These features include: (1) content and skill-focused, (2) support collaboration, (3) incorporate active learning, (4) use models of effective practice, (5) offer feedback and reflection, (6) is of sustained duration, and (7) provides coaching and expert support. Furthermore, Asghar and colleagues (2012) showed that pedagogical components tied up with subject-matter content knowledge in a TPDP produced positive results. Similarly, Bransford and colleagues (2000) defined several factors on designing and developing TPDP for STEM teachers, such as: "(a) deepening teachers' content knowledge of STEM concepts, (b) developing teachers' pedagogical content knowledge in STEM areas, (c) engaging them in cooperative learning, (d) seeking teachers' input on their learning, and (e) inviting teachers to write about their students' learning to uncover their struggles with learning science and mathematics" (p. 78). These factors for STEM teachers can be extended to STEAM teachers.

With this information, a training design derived from the validated framework was conceptualized by the researcher to come up with a customized TPDP for the STEAM Education framework.



The Developed Training Design

The degree to which training has been developed and delivered to offer trainees the capacity to transfer learning to work is referred to as training design. The planning and determination of acceptable activities to be carried out, selecting appropriate techniques, and resolving sources to accomplish specific training program objectives are all parts of the design (Alias et al., 2019). Thus, the training design considers the content, goals, and methods on how the TPDP will be delivered. The learning concepts, chances for practice, training objectives, and effective instructional techniques should be incorporated into the design. Arabi (2020) argued that knowledge acquisition, skill advancement, and attitude modification should be addressed in it. Hence, the researcher made the training design strategic to improve the abilities, skills, and knowledge of STEM teachers and administrators to aid them during the implementation of STEAM Education in the SHS STEM Strand.

There are various training design aspects that impact training transfer according to the training literature. As a result, organizations should consider such elements while developing a training program to improve training transfer. Jehanzeb and Bashir (2013) listed essential elements to be considered in drafting training design: learning style, budget, delivery mode, content, timeline, the effectiveness of training, learning objectives, and audience. In this study, the researcher considered only content, training/learning objectives, delivery mode, audience and learning style, and the timeline for developing the training design.



Philippine Normal University National Center for Teacher Education

Training Content and Objectives

A TPDP starts with the identification of desired outcomes. These outcomes may be translated to training objectives based on the identified needs during the interviews and aligned with the validated framework standards. The identified needs serve as the gaps or markers to determine the content of the training. Training objectives give the track for training content and provide the parameters for assessing the desired accomplishments. The following are the proposed training objectives.

The TPDP on STEAM Education for SHS STEM Strand is designed to:

- 1. Inform the SHS STEM teachers and administrators about STEAM education*
- 2. Acquaint the SHS STEM teachers and administrators with the validated STEAM Education Framework for SHS STEM Strand*
- 3. Serve as a venue for the participants in developing activities and new strategies in incorporating STEAM teaching and learning in their school*
- 4. Develop the capability of teachers in incorporating arts in lessons and recognize design thinking as an innovative tool for creating STEAM lessons*
- 5. Help STEM teachers to create authentic STEAM lessons and assessment*
- 6. Support the teachers and administrators to enhance their STEAM-related skills*
- 7. Equip administrators the sufficient knowledge and skills in supervising STEM teachers in terms of management, administration, and leadership*
- 8. Assist teachers and administrators in constructing and maintaining a safe learning space for students in a STEAM classroom*
- 9. Improve the linkages and connection with different stakeholders to involve them in the STEAM curriculum*



Philippine Normal University National Center for Teacher Education

In line with the training objectives, the design in TPDP was sequenced in a series of programs or modules where specific learning goals are established that define the actions that must occur. The effectiveness of the TPDP can be determined if the participants demonstrably achieve the learning goals in each module. Table 23 lists the needs identified during the interview, the proposed training module, and specific learning goals.

Table 23. The proposed training module and its specific learning goals.

Identified Needs	Title of Module	Learning Goals
Identification of key features of STEM and STEAM Education	Lenses of STEAM Education: Theories and Practices	To gain knowledge about STEAM Education To understand the critical features of STEAM Education
Recognition of needs and constructs in the STEM curriculum and its translation to STEAM education	The Validated STEAM Education Framework for SHS STEM Strand: Principles, Components, and Elements	To identify the key areas that need to be strengthened for STEAM Education To know the salient features of the validated STEAM Education Framework for SHS STEM Strand
Integration of arts	From STEM to STEAM: Integration of Arts in STEM Subjects	To incorporate art in topics or lessons on different subjects



		To learn design thinking as an innovative tool for creating creative STEAM lessons
Enrichment of Pedagogical strategies of STEM Teachers		To learn novel pedagogies that could be used in a STEAM classroom
Development of students' skills	Innovative Pedagogies in STEAM Education	To demonstrate different STEAM teaching strategies
Enhancement of teachers' content and pedagogical knowledge		To share best practices of teachers for the students to express their creativity
Lack of teaching and learning resources	Designing STEAM Lessons and Activities: Context of Limited Materials and Lack of Laboratory Rooms	To relate and connect different subject areas through creative STEAM lessons
Lack of training in using lab equipment		To write, present, and critique lesson exemplars highlighting innovative STEAM curriculum
Limited learning materials		To create authentic STEAM lessons despite limited materials and lack of laboratory classrooms
Lack of laboratory rooms		
Enhancing technological, research, communication, and social-emotional	Capacitating Educators in STEAM-related Skills	To capacitate educators in the skills relevant to



competencies		STEAM Education in terms of technological, research, communication, and social-emotional competencies
		To strengthen the teachers' knowledge and skills
Effective assessment tool		To familiarize STEAM educators in the assessment tools and strategies used in STEAM Education
Innovative assessment strategies	Designing Assessment in STEAM-based Curriculum	To design authentic assessment based on real-life and concrete experiences
Diversity and inclusivity		To define classrooms conducive for STEAM teaching and learning
Classroom Management	Safe STEAM Education Learning - Teaching Environment	
Security		To formulate effective methods in maintaining a safe learning space for students in a STEAM classroom
Free from discrimination		
Administrators' support	STEAM Transformative Leadership: Sound Administration and Effective Management	To equip STEM administrators' knowledge and skills in supervising STEAM Teachers
Administrators' effective management		
Administrator leadership		



		To recognize efficient management techniques in a STEAM environment
Partnership with stakeholders	Stakeholders' Involvement in STEAM Curriculum: Support and Partnerships	To recognize and employ effective strategies in establishing connections and linkages with different stakeholders
Establishing linkages with community		
Getting support from LGUs and NGOs		To involve other stakeholders in STEAM Education Curriculum
Parent collaboration		

The researcher proposed ten modules for the training design along with its specific learning goals. The first module (Lenses of STEAM Education: Theories and Practices) presents the key features of STEM and STEAM Education while the second module discusses the validated STEAM Education Framework for SHS STEM Strand along with its elements, components, and principles. The second module will also have a group sharing activity wherein the participants will identify critical areas in their school that are needed to be strengthened for STEAM education. The third module titled "From STEM to STEAM: Integration of Arts in STEM Subjects" aims to capacitate STEM teachers to incorporate arts in their lessons and familiarize them with design thinking as a tool in creating STEAM lessons. Design thinking will help science teachers generate creative and interdisciplinary pedagogies as a support system in their STEAM teaching.



Philippine Normal University National Center for Teacher Education

Understanding the design thinking principles such as empathy, defining the problem, ideation, prototype, and testing (Henriksen, 2017) through a workshop is also part of the module activities.

The fourth module will discuss the pedagogical methods and techniques that teachers in their STEAM teaching can employ. Demonstration teaching is also an activity in this part of training for the participants to showcase the different STEAM teaching strategies. Group sharing is also a recommended activity for this module for the STEM teachers to share their best practices on how students will express their creativity. Meanwhile, the fifth module talks about STEAM teaching and learning even without materials and laboratory rooms. In this module, participants are expected to produce a lesson exemplar wherein presentation and critiquing will be conducted to improve the developed exemplars. The mentioned activities will be done through a writing workshop.

The sixth module will focus on enhancing the STEAM-related skills of teachers and administrators such as technological, research, and social-emotional competencies. Further, the seventh module will familiarize the participants with the different assessment tools and strategies appropriate in STEAM education. In this module, the participants are expected to design an authentic assessment based on real-life and concrete experiences. Moreover, the eighth module will discuss creating and maintaining a safe learning STEAM environment. On the other hand, the ninth module titled "STEAM Transformative Leadership: Sound Administration and Effective Management," aims to equip STEM administrators' knowledge and skills in supervising STEAM Teachers and



Philippine Normal University National Center for Teacher Education

managing school resources. Lastly, the tenth module gave importance to the involvement of stakeholders in providing quality STEAM education.

With these modules, the training could serve as second-tier validation for the framework. The training objectives, the modules, and the specific learning goals will be the overarching roadmap for the TPDP.

Training Modality

Training modality that balances cost and the need to keep learners engaged is one of the aspects the researcher considers in crafting the training design. E-learning, experiential learning, one-to-one learning, blogging and discussion, video-conferencing, seminars, face-to-face workshops, group learning activities, self-study programs, and among many others are examples of the different methodologies that could be used in training design. Each of these delivery modalities has its own set of advantages and disadvantages. Trainees' ability to take time off and travel for training, availability of in-house expertise, and regulatory or policy requirements that may require the use of certain delivery methods or training professionals are all factors to consider when deciding on delivery methods. Training should be tailored to guarantee the trainees' highest level of involvement in the most cost-effective and long-term way possible (Martin, Kolomitro, & Lam, 2014). Using a combination of distribution modalities may typically alleviate the drawbacks of a single approach while still meeting learning objectives (Mohammed, Killingsworth, & Shah, 2021).



Philippine Normal University National Center for Teacher Education

The present situation caused by the COVID19 pandemic has brought many changes in the world. The unclear future that this pandemic may still bring creates significant challenges in many industries, even in the education sector (Jorge, 2020). To cope with this pandemic, strict health measures have been set that affect many people's daily lives. The term "New Normal" has been coined to describe this adjustment. Many face-to-face (F2F) transactions, including training, have been prohibited in the "new normal" until now in the Philippines due to COVID19 high cases.

Different modalities have been incorporated in training programs to make it so flexible. The common modality of delivering TPDP is face-to-face instruction. However, the advent of technology paved the way for other modalities such as web-based training (WBT) commonly known as online training and computer-based training (CBT). These alternative modalities are becoming popular since face-to-face training programs require many resources. CBT can be defined as training with the use of computers that is why it is also called as computer-assisted instruction (CAI). It is easy and convenient but maybe highly expensive since the need for computers. However, the privacy, ease of learning, and even without internet connection in CBT are promising to the participants of this type of training. The main disadvantage of CBT is it is only accessible through computers and where the training program is installed (Alamani, 2010). The CBT is different from the online training wherein the materials can be accessed anywhere and anytime and accessible through mobile phones and other devices with internet capability. Cost-effectiveness, flexibility, and the capacity to reach larger audiences are the primary reasons some opt to have online training (Aggarwal et al., 2011; Caravias, 2014; Curran,



Philippine Normal University National Center for Teacher Education

Fleet, & Kirby, 2010; Gedera, 2014). Collaborative learning and being independent are also some of the features of online training.

Moreover, online training "fulfills the motivations, expectations, and approaches to learning of this new generation of people." These benefits of online training were expounded by Fahy (2019), stating that "Online training can offer valuable advantages over other types of training delivery in a wide variety of public and private environments: training time and travel can be reduced, even eliminated, lowering costs; materials stored on central servers can be continually revised and updated, assuring currency and enhancing quality; training content is more consistent, supporting higher standards; greater efficiency (chiefly the result of individualization) can increase trainee learning and satisfaction, improving motivation; and production and delivery of training programs may be more systematic, improving the cost-effectiveness of development" (p. 20). However, online training is also criticized for needing a stable internet connection, briefness, and compliance-oriented (Allen & Seaman, 2011; Caravias, 2014; Ogunrin, Ogundiran, & Adebamowo, 2013).

Thus, the researcher suggests a "flexible" teacher professional development program (FTPDP) on STEAM Education for senior high school science teachers which is suitable to be conducted in either face to face (F2F), online (synchronous), online (asynchronous) or a hybrid of this modality which the implementation thereof will depend on the situation caused by COVID19 pandemic. The content of the developed module may be translated into different modalities to be utilized based on the situation warranted.



Philippine Normal University National Center for Teacher Education

Audience and Learning Style

The intended audience for the TPDP for STEAM Education is STEM Teachers and administrators aged 21 to 60 and are considered adults. This information is important since in developing training programs, it is critical that the learning style of the trainees must be considered. From experience, the researcher knows that everyone has a learning style or styles that they are most at ease with. Some people learn better as part of a group, while others learn best when working alone. Some people learn better with hands-on experience, while others learn better when provided with notions and theories.

Pedagogy, or the process of assisting children in learning, has long been understood by educators. However, it was not until 1970, when Malcolm Knowles invented the term andragogy to describe how adults learn, that we began to consider how adult learning differed from children. Adults offer a unique set of characteristics to the classroom. They want their personal experiences to be infused into their education. When they have a problem to solve, they are motivated to learn. As a result, they are more engaged in the details of an issue than the broad area. Being a student is typically not an adult's primary responsibility; it comes second to their other responsibilities. Adult learning is very different from child learning since adults and children have different contexts that differentiate their learning needs (Knowles, Holton, & Swanson, 2005; Lawler, 2003). TPDP is considered as adult education since teachers are adult learners (King & Lawler, 2003; Levin, 2003). Gregson and Sturko (2007) also argued that "teachers, like other professionals, learn by participating in the activities that are socially



Philippine Normal University National Center for Teacher Education

and culturally situated within their profession" (p. 1). Thus, the developed training program must be conducive to adult learning. Knowles (1980) discussed this "art and science of teaching adults" as andragogy. In this concept, adults are perceived as independent, self-directed, and intrinsically motivated learners. Also, adult learners are characterized as problem-focused and more inclined to immediately apply the skills and knowledge (Herod, 2012). In andragogy, the learning environment is characterized by mutual respect and cooperation. Planning and assessment are collaborative between the learners and the teachers.

Furthermore, the teaching process is more on independent study, experimentation and inquiry projects. In addition, evaluation in andragogy is more of a self-assessment (Trotter, 2006). According to Knowles (1990), when developing and planning a training program or instruction for adult learners, five assumptions must be learned and incorporated to become effective. The first assumption is that "adults are motivated to learn when they need to know new skills" (p. 12). Next, adults learn throughout their lifetime, and the learning can be acquired through their experiences. The third assumption is that the learning of adults should be self-directed and based on their age which causes individual differences to exist. Fourth is that adults want to learn the skills that "can be immediately utilized in the classroom, participate in problem-solving activities, and discuss practices with others" (Bishop, 2016, p.21). And lastly, adults, through learning, should become more oriented on the task of their social roles in society.

Hence, the training program should try to cater to as many learning types as feasible in the training sessions since there are various learning methods that individuals



Philippine Normal University National Center for Teacher Education

are comfortable with. This situation can be achieved by providing a variety of learning tactics such as small group exercises, hands-on activities, and information for individual study. The training sessions should include specific, relevant examples, and each session should be tailored to the trainees' interests. In addition, the humanistic paradigm entails that the facilitation of adult learning is collaborative in nature (Nath, Kumar, & Behura, 2017). The paradigm emphasizes "the negotiation of objectives, methods and evaluation criteria in a learning encounter between adult learners and the facilitators" (Wang, 2007, p. 3). With this, respect for adult learners' integrity, interests, and demands in realizing their needs should always be remembered. Thus, the TPDP must be formed as "a partnership rather than as an authoritarian transmission of information from the experts to the ignorant." (Kaur, 2001, p.118) This is following the adult learning theory that adults are self-directed learners whose experience is a rich learning reservoir.

When these adult learner traits are combined with their diverse learning styles and learning theories, the result is a complex combination that must be addressed for the training to be effectively accepted and suit the demands of the adult audience. Thus, group sharing, demonstration teaching, workshops, and lecture-discussion serve as the main activities for the training program.

Training Matrix

It is deemed effective when a training design solves a knowledge or skill gap and prepares teachers for the future with new skills (Sheeba & Christopher, 2020). Using the proposed module content and learning objectives as guides, how long and detailed the



Philippine Normal University National Center for Teacher Education

content and how it should be presented could be assessed. Also, appropriate training materials that incorporate assessment and various learning styles and aligned lesson plans could be produced from these data.

The researcher crafted a six-day training program for STEM teachers to prepare them in STEAM Education (Table 24). The timeline and time allotment per activity are shown in the table. The training matrix for teachers comprises nine modules and a maximum of six hours of participation per day is expected. Further, the training activities involve various adult learning strategies such as lecture-discussion, workshop, demonstration, and group sharing. In addition, a training program for administrators (Table 25) was also crafted aligned with the needs of administrators during the development of the framework. The crafted training program is in consonance with the study of Moon (2020), wherein administrators complain about the lack of STEAM professional development training; thus they have no knowledge on how to give sustenance to their teachers regarding STEAM instruction. In this regard, modules in the training program of teachers were also part of the training for the administrator so that administrators will have the necessary knowledge on what the teachers are expected to do in STEAM education. Their training is expected to be finished after five days with ten modules to be accomplished.



Philippine Normal University

National Center for Teacher Education

Table 24. The Proposed Training Matrix for STEM Teachers

Day	Module	Activities	Time Allotment	Specific Learning Goals	Modality
1	Lenses of STEAM Education: Theories and Practices	Lecture-Discussion	2 hours	To gain knowledge and understand the critical features of STEAM Education	Flexible (face to face, synchronous, asynchronous, or hybrid of mentioned techniques)
	The Validated STEAM Education Framework for SHS STEM Strand: Principles, Components, and Elements	Lecture-Discussion	2 hours	To know the salient features of the validated STEAM Education Framework for SHS STEM Strand	
		Group sharing	2 hours	To identify the key areas in the participants' school that need to be strengthened for STEAM Education	
2	From STEM to STEAM: Integration of Arts in STEM Subjects	Lecture-Discussion	2 hours	To incorporate art in topics or lessons on different subjects using the design thinking principle	
		Workshop (Empathy, Defining the Problem, Ideation, Prototype, Testing)	4 hours	To practice the design thinking principle such as empathy, defining the problem, ideation, prototype, and testing	
3	Innovative Pedagogies in STEAM Education	Lecture-Discussion	2 hours	To learn novel pedagogies that could be used in a STEAM classroom	
		Demonstration Teaching	2 hours	To demonstrate different STEAM teaching strategies	



Philippine Normal University

National Center for Teacher Education

		Group Sharing	2 hours	To share best practices of teachers for the students to express their creativity	
4	Designing STEAM Lessons and Activities: Context of Limited Materials and Lack of Laboratory Rooms	Lecture-Discussion	2 hours	To relate and connect different subject areas through creative STEAM lessons	Flexible (face to face, synchronous, asynchronous, or hybrid of mentioned techniques)
		Writing Workshop (development of lesson exemplars)	2 hours	To create authentic STEAM lessons despite limited materials and lack of laboratory classrooms	
		Presentation and critiquing of lesson exemplars	2 hours	To write, present, and critique lesson exemplars highlighting innovative STEAM curriculum	
5	Capacitating Educators in STEAM-related Skills	Lecture-Discussion	3 hours	To capacitate educators in the skills relevant to STEAM Education in terms of technological, research, communication, and social-emotional competencies	
	Designing Assessment in STEAM-based Curriculum	Lecture-Discussion	3 hours	To familiarize STEAM educators in the assessment tools and strategies used in STEAM Education and design an authentic assessment based on real-life and concrete experiences	
6	Safe STEAM Education Learning - Teaching Environment	Lecture-Discussion	2 hours	To define classrooms conducive for STEAM teaching and learning	



Philippine Normal University

National Center for Teacher Education

		Group Sharing	2 hours	To formulate effective methods in maintaining a safe learning space for students in a STEAM classroom	
	Stakeholders' Involvement in STEAM Curriculum: Support and Partnerships	Lecture-Discussion	2 hours	To recognize and employ effective strategies in establishing connections and linkages with different stakeholders	



Philippine Normal University
National Center for Teacher Education

Table 25. The Proposed Training Matrix for STEM Administrators

Day	Module	Activities	Time Allotment	Specific Learning Goals	Modality
1	Lenses of STEAM Education: Theories and Practices	Lecture-Discussion	2 hours	To gain knowledge and understand the critical features of STEAM Education	Flexible (face to face, synchronous, asynchronous, or hybrid of mentioned techniques)
	The Validated STEAM Education Framework for SHS STEM Strand: Principles, Components, and Elements	Lecture-Discussion	2 hours	To know the salient features of the validated STEAM Education Framework for SHS STEM Strand	
		Group sharing	2 hours	To identify the key areas in the participants' school that need to be strengthened for STEAM Education	
2	From STEM to STEAM: Integration of Arts in STEM Subjects	Lecture-Discussion	2 hours	To incorporate art in topics or lessons on different subjects using the design thinking principle	
		Workshop (Empathy, Defining the Problem, Ideation, Prototype, Testing)	4 hours	To practice the design thinking principle such as empathy, defining the problem, ideation, prototype, and testing	
3	Innovative Pedagogies in STEAM Education	Lecture-Discussion	2 hours	To learn novel pedagogies that could be used in a STEAM classroom	
	Designing STEAM Lessons and Activities: Context of Limited	Lecture-Discussion	2 hours	To relate and connect different subject areas through creative STEAM lessons	



Philippine Normal University

National Center for Teacher Education

	Materials and Lack of Laboratory Rooms				
	Stakeholders' Involvement in STEAM Curriculum: Support and Partnerships	Lecture-Discussion	2 hours	To recognize and employ effective strategies in establishing connections and linkages with different stakeholders	
4	Capacitating Educators in STEAM-related Skills	Lecture-Discussion	3 hours	To capacitate educators in the skills relevant to STEAM Education in terms of technological, research, communication, and social-emotional competencies	Flexible (face to face, synchronous, asynchronous, or hybrid of mentioned techniques)
	Designing Assessment in STEAM-based Curriculum	Lecture-Discussion	3 hours	To familiarize STEAM educators in the assessment tools and strategies used in STEAM Education and design an authentic assessment based on real-life and concrete experiences	
5	Safe STEAM Education Learning - Teaching Environment	Lecture-Discussion	2 hours	To define classrooms conducive for STEAM teaching and learning	
		Group Sharing	1 hour	To formulate effective methods in maintaining a safe learning space for students in a STEAM classroom	
	STEAM Transformative Leadership: Sound Administration and Effective Management	Lecture-Discussion	2 hours	To equip STEM administrators' knowledge and skills in supervising STEAM Teachers	
		Sharing of Best Practices	1 hour	To recognize efficient management techniques in a STEAM environment	



Philippine Normal University National Center for Teacher Education

The mentioned parameters such as content, training/learning objectives, delivery mode, audience and learning style, and the timeline for training design will be considered in developing the TPDP for senior high school science teachers on STEAM Education. The developed training design aims to contribute to the professional growth of the teachers and is expected to contribute to the enhancement of policies and to serve as the basis for STEAM instruction. The crafted training program hopes to guide future training and workshops of DepEd for STEAM teachers. Through these principles, an enhanced SHS STEAM curriculum is expected.

Validation Result of Training Design and set of Indicators and Standards

The same Delphi technique used in the validation of the framework was employed to validate the training design and the set of indicators and standards. Also, the mentioned outputs were validated by the same panel of experts who validated the framework. For this validation, two rounds were conducted before a consensus of acceptance of the training design and a set of standards and indicators was attained.

In the first round of validation using an open-ended questionnaire (Appendix AK, comments of the validators included that the principles, features, and components of the crafted training design and set of standards and indicators are comprehensive, complete, holistic, and organized (Appendix AL). The validators describe the outputs as well-defined, well-crafted, and really captured the essence of STEAM education. Further, all validators agree that the training design and the set of indicators and standards vividly elaborate the STEAM education framework. In this regard, one of the validators notes



Philippine Normal University National Center for Teacher Education

that the topics included in the training design clearly explained the contents and purpose of STEAM education, while another validator believes that the outputs provided detailed standards and clear indicators for all aspects for successful implementation of STEAM. A validator remarked,

"... the outputs provide numerous principles on how the education could be better by exploring its overlooked grey areas. The realities are well-discussed as to craft an adaptable learning structure for changing and unpredictable global development of education and curriculum."

Specifically for training design, all validators affirm that the training design could prepare STEM teachers for the possible implementation of STEAM Education in Senior High School. One of the validators reasons out that the training design will surely help prepare STEM teachers as the needed competencies and skills requirement of STEAM Education is part and parcel of the training, while another validator claimed that the training design offers a holistic and comprehensive view for implementation of STEAM education. In literature, TPDP has been proven effective in preparing teachers in implementing the STEAM curriculum, as well as, in ensuring creative ability and providing motivation (Conradty & Bogner, 2020). In addition, a validator claims that the training design is "contextualized where each component is coordinated to support the kind of educational structure on how STEAM curriculum and the broad spectrum of arts relate to the realities of the school community as a whole." The validator further observes that the design explains how all divisions of education and its workforce work in harmony for purposeful integration of the exploratory subjects which are critical in learner's development.



Philippine Normal University National Center for Teacher Education

Moreover, a validator stated that the training design is well-crafted for STEM teachers, and using this in preparation for STEAM education would help achieve the program's objectives. He also believes that the modules are logical as they start with the theory down to partnership with LGU and stakeholders, and in effect, will support the teachers develop their soft skills and hard skills. Similar findings on improvement in the teachers' content and pedagogical knowledge, skills, and attitudes due to their participation in various training programs were perpetuated by National Academies of Sciences, Engineering, and Medicine (2015).

In terms of the standards and indicators, the validators unanimously agree that these could be used to assess the quality of STEAM education in Senior High School since (1) standards and indicators are well defined following the stipulated competencies and skill requirements needed by it, (2) it reflects the purpose of the STEAM education and is contextualized on what is happening in the field, (3) the indicators have the impression that such can use to assess the quality of proposed STEAM Education, (4) the indicators speak not only during normal circumstances where face-to-face learning is allowed but also provide the necessary measures to maintain quality education even during the pandemic, and (5) since the crafted standard and indicators are holistic in nature. Lewin (2015) highlighted the importance of standards and indicators as measures of progress towards targets and gave precautions on the dilemma it may cause. According to him, setting high criteria for indicators and standards will likely fail to reach the level, while setting low criteria may only produce low-quality performance since improvement will not be encouraged.



Philippine Normal University National Center for Teacher Education

However, some suggestions were still proposed by validators, especially on standards and indicators. One of the validators proposed incorporating a "safe" atmosphere for STEAM teachers to provide feedback or evaluation of the curriculum since, based on her study, teachers feel hesitant to give feedback on the curriculum even when they think it is not appropriate or working. The validator believed that teachers, being one of the front liners in the curriculum implementation, know how the curriculum is operationalized and making them feel safe providing inputs might be necessary. The same validator also suggested the indicators for arts integration to be more transparent and explicit on promoting student creativity because arts integration is one part of STEAM education that most teachers struggle with. This comment is aligned with several reports claiming that teachers were being pressured to integrate Arts in STEM disciplines to the needed STEAM Education (English, 2017). Science teachers are challenged to incorporate the Arts field into STEM disciplines as some are not artistic while others do not appreciate the integration of arts in the STEM disciplines (Henriksen, 2017). This occurrence lessened teachers' confidence towards STEAM teaching and made some teachers perceive STEAM education as a task-oriented approach than pedagogy (Jamil, Linder, & Stegelin, 2017).

Furthermore, a validator proposed merging cells under each module, providing possible activities, and making the choices as broad as possible. The validator claimed that the reality on the ground shows that many schools are likely to simply interpret the "proposed" matrix as the standard or expected format for delivery. The validator believed that there would be a greater chance that the learning style diversity would be considered



in training design implementation if this suggestion is incorporated. Table 26 summarizes the suggestions and comments of the validators for the training design and set of indicators and standards and the actions done by the researchers in each suggestion.

Table 26. Summary of suggestions of validators for the developed training design and set of indicators and standards and the researcher's action

Validation Question	Remarks	Revisions Made
Can the set of indicators and standards be used to assess the quality of STEAM education in Senior High School? Please elaborate.	Yes they could. I only have reservations with the indicators for Arts integration. Isn't this incorporated to promote creativity among the learners? Would these indicators be enough to promote student creativity? The paper mentioned earlier that art integration is one part of STEAM education most teachers struggle with. So I guess this part should be more clear and explicit on how to promote student creativity through arts integration. (Validator 2)	The indicators for the arts integration were stated more explicitly and an additional indicator was also added to provide more clarity on how students' creativity will be promoted.
If you were to craft the training design and set of indicators and standards, what other principles, features, or components would you include?	I will include the same principles, features, and components as they are already complete and comprehensive enough to capture the STEAM Education Framework. (Validator 1)	
	For the curriculum refinement/ policy standard, would it be possible to incorporate "safe" atmosphere for STEAM teachers to provide feedback or evaluation of the curriculum? Based on my own study, teachers feel hesitant to give	An indicator incorporating a "safe" atmosphere for STEAM teachers to provide feedback or evaluation of the curriculum is also added on the



	feedback on the curriculum even when they feel it is not appropriate or working. Although technically, they are allowed to make reports on feedback on curriculum, they feel that it is against the expectations. However, teachers being the frontliners in curriculum implementation, they know how this is operationalized so making them feel safe providing inputs might be important. (Validator 2)	standard.
	The training design and set of indicators and standards are already comprehensive and complete. I will not add anything. (Validator 3)	
	Honestly, I am overwhelmed with the training designs. I have no more to say but to express my excitement about its implementation. (Validator 4)	
	I think they are all complete to cover the goals of the STEAM education in the Philippines. (Validator 5)	
Do you have any suggestions or comments for improving the training design and set of indicators and standards? Please provide the details.	I think the training design and set of indicators and standards are already comprehensive. Thus, I have no suggestion or comment anymore. (Validator 1)	
	I appreciate the recognition of andragogy and learning preferences or styles of target learners. However, reality on the ground shows that many schools are likely to simply interpret the "proposed" matrix as	The term "activity" was revised to "suggested activities" so that the training implementer will have discretion on the activity they want.



Philippine Normal University National Center for Teacher Education

	the standard or expected format for delivery. Hence, for the Proposed Training Matrix, would it be possible to simply merge the cells under each module and provide "Possible activities" and make the choice as broad as possible. This way, there would be a greater chance that learning style diversity will be considered in its implementation. (Validator 2)	
	Just like in the previous question, I have no suggestion or comments anymore. (Validator 3)	
	The indicators, features, and standards are all set in. I am praying and hoping that this framework will introduce soon. (Validator 4)	
	None. The training design and set of indicators and standards are already in order. (Validator 5)	

All comments of validators were noted and all of the suggestions were incorporated with the approval of the researcher's adviser. For the second round of validation, another validation tool was given to the experts (Appendix AM). This tool involves a questionnaire composed of 25 statements answerable in a five-point Likert scale to express their agreement or disagreement. The statements are divided into 15 statements for the training design and ten statements for the set of standards and indicators. The comments of the validators from the first Delphi round and the questionnaires from different works of literature served as the basis of items in the



questionnaire for the second Delphi round (Nordin et al., 2012). The validation tool (Appendix AL), the revised proposed training matrix, the set of indicators and standards from the first Delphi round, and the summary of the changes and revisions (Appendix AJ) were given to the panel of experts. The same with the Delphi method described in the framework validation, the training design and the sets of indicators and standards were considered valid when at least an average rating of 3.75 in each item is obtained from the experts. Tables 27 and 28 show the result of their evaluation in each area of validation.

Table 27. The result of validation for training design

Statement	Mean Score	Interpretation
The training design is comprehensive and well-crafted.	5.00	Strongly agree
The objectives of the training are clearly defined.	5.00	Strongly agree
The training design is aligned to the training objectives and learning goals.	5.00	Strongly agree
The topics covered or modules in the proposed training are relevant for the participants.	5.00	Strongly agree
The module of the proposed training is organized and easy to follow.	5.00	Strongly agree
The duration of the training in the training design is adequate.	4.80	Strongly agree
The training design is feasible to be implemented.	5.00	Strongly agree
The training design vividly elaborates the STEAM education framework.	5.00	Strongly agree
The training design will help participants in the preparation of STEAM education implementation.	4.80	Strongly agree
The participants will learn from this training design if this is implemented.	4.80	Strongly agree



Philippine Normal University National Center for Teacher Education

The participants will gain a deeper understanding of STEAM education and the validated STEAM education framework through the crafted training design.	4.80	Strongly agree
The training design offers a holistic and comprehensive view for the implementation of STEAM education.	5.00	Strongly agree
The training design clearly encourages participation and interaction from the intended participants.	5.00	Strongly agree
The principles, features, and components of the training design are well defined and capture STEAM education well enough.	4.80	Strongly agree
Overall, the design of the training is satisfactory.	4.80	Strongly agree
OVERALL MEAN	4.92	

The second round of validation reveals that validators strongly agree that the training design and the set of standards and indicators are excellent, with an overall mean of 4.92 and 4.96, respectively. For the content and organization of the training design, the validators approved that it is comprehensive and well-crafted. Also, the validators strongly agree that the training objectives are clearly defined and the training design is aligned to the training objectives and learning goals. The topics covered or modules in the proposed training are relevant for the participants and are organized and easy to follow. They also agree that the duration of the training in the design is adequate and is feasible to be implemented.

Furthermore, the validators believe that the participants would learn and understand STEAM education and the validated STEAM education framework through the crafted training design. Overall, for them, the design of the training is satisfactory.



Ritzmann, Hagermann, and Kluge (2014) stated that a satisfactory training design would likely lead to an effective training program.

Table 28. The result of validation for indicators and standards.

Statement	Mean Score	Interpretation
The standards and indicators are holistic and organized.	5.00	Strongly agree
The standards and indicators are practical and substantial.	5.00	Strongly agree
The standards and indicators are clear and detailed.	5.00	Strongly agree
The standards and indicators are stated explicitly for their intended purpose.	5.00	Strongly agree
The standards and indicators are justifiable, comprehensive, and specific.	5.00	Strongly agree
The principles, features, and components of the standards and indicators are well defined and capture STEAM education well enough.	4.80	Strongly agree
Standards and indicators are well suitable in the present conditions of the teachers and administrators in a school setting.	5.00	Strongly agree
The set of indicators and standards can be useful to assess the quality of the STEAM Education in the country.	5.00	Strongly agree
The standards and indicators vividly elaborate the STEAM education framework.	5.00	Strongly agree
The standards and indicators provide a glimpse on the possible contents and purpose of STEAM education for Senior High School.	4.80	Strongly agree
OVERALL MEAN	4.96	



Philippine Normal University National Center for Teacher Education

In terms of standards and indicators, Table 28 shows that the validators strongly agreed for all the statements. The validators approved that the standards and indicators are holistic, organized, practical, substantial, clear, detailed, justifiable, comprehensive, and specific. Also, the validators strongly agree that the standards and indicators are stated explicitly for their intended purpose and are well suitable in the present conditions of the teachers and administrators in a school setting. Furthermore, the validators believe that the standards and indicators provide a glimpse of STEAM education's possible contents and purpose for Senior High School.

Validated Training Design and Set of Indicators and Standards

After incorporating the suggestions of the validators, Table 29 shows the validated set of indicators and standards while Tables 30 and 31 show the validated proposed training matrix for teachers and administrators, respectively.

Table 29. The validated set of standards and indicators.

Standards	Indicators	Proofs needed for verification
<i>Teacher Qualifications</i>	The teachers have specialization aligned with the subject they teach	Diploma
	The teachers possess advanced degrees such as master's or doctor's degrees relevant to the subject they teach	Transcript of Records (TOR)
	The teachers are passers of the Board of Licensure Examination for Professional Teachers (BLEPT)	Professional Regulation Commission (PRC) License
		Copy of Certificate/s of Training attended
		Service Record



	The teachers have specialized training on the subject which they teach	
	The teachers have sufficient teaching experience	
Teacher Competencies	The teachers have a strong foundation and understanding of science, technology, engineering, arts, and mathematics (STEAM) subjects in terms of content knowledge.	Research proposal/ Research publication Copy of certificate of attendance or presentation in training, seminar, or workshop Copy of certification of active membership and ID Lesson exemplar with details on technology integration
	The teachers exhibit research skills by conducting research related to STEAM teaching and learning.	
	The teachers continuously promote their lifelong learning competencies by attending and presenting in training, seminars, and workshops.	
	The teachers participate or are actively involved in professional organizations relevant to their field.	
	The teachers demonstrate technological skills in their teaching.	
Arts integration	Through a method that blends context and content, the teacher continually involves numerous disciplines such as arts, engineering, and mathematics.	Lesson Exemplar Morales et al. (2019) Classroom Observation Tool Instructional materials utilized during the lesson
	The teachers provide a curriculum that effortlessly combines	



	knowledge from several subjects.	proper
	To satisfy the educational needs of distinct disciplines, the teachers frequently employ a range of instructional tactics and methodologies.	
	Frequently, the teachers explicitly combine various subjects complementing the students' creativity.	
	The teachers incorporate arts in their teaching which reflects through students' outputs and presentations.	
Teacher Pedagogical character	The teachers provide real-world tasks in which students can develop communication and teamwork skills by participating in a range of relevant learning exercises.	Lesson Exemplar Morales et al. (2019) Classroom Observation Tool Copy of student evaluation Instructional materials utilized during the lesson proper
	The teachers give instructions and demonstrate several tools and strategies that students can use while developing creative solutions.	
	The teacher constantly offers meaningful learning not only through cooperative and collaborative pedagogies but also through critical and reflective pedagogies.	
	The teachers frequently use various learning styles to encourage students to think of numerous	



	solutions to a problem.	
Assessment Practices	Teachers have knowledge on using assessment tools and strategies appropriate in STEAM instruction and utilize them effectively.	Lesson Exemplar Morales et al. (2019) Classroom Observation Tool
	Teachers use the assessment data to proactively solve the challenges they face in the STEAM teaching-learning process.	Copy of the assessment and rubrics used Copy of student evaluation
	Teachers collaborate with each other in planning, implementing and monitoring of assessments.	Instructional materials utilized during the lesson proper
Curriculum refinement	The lessons intended to be taught in a subject can be finished for the school year.	Lesson exemplars
	Each subject has an intended teaching and learning guide.	Teaching and learning guides
	The school provides adequate materials and laboratory equipment.	Inventory of materials and laboratory equipment
	The school has sufficient laboratory rooms.	List of laboratory rooms in the school
Safe Learning Space	The teachers create a conducive classroom environment to facilitate STEAM learning.	Lesson exemplars
	The school provides a secure environment that acknowledges diversity and inclusivity and is free from discrimination.	Copy of student evaluation Copy of school records



	The teachers have defined and practiced classroom rules and procedures.	
	The teachers teach discipline among students.	
<i>Sound Administration and Effective Management</i>	The administrators support their teachers in terms of attendance in training, seminar, or workshop.	
	The administrators provide well-defined decisions and create learning innovations.	List of teachers who attended training
	The administrators establish educational networks and strengthen educational connections.	Accomplishment report
	The administrators participate in a professional development program.	Copy of certificate of trainings/workshop/seminars attended
	The administrators lead curriculum and development implementation and establish a learner-centered atmosphere.	
<i>Policy Orientation and Harmonization</i>	The school admits students based on grades and entrance examinations.	Result of entrance examination
	The teachers teach their subjects aligned with their specialization.	Copy of the workload of teachers
	The school offers subjects in the same schedule as other schools.	Copy of syllabus
	The teachers are provided ways and means to give feedback or evaluation of the curriculum safely.	Teachers' Assessment Sheet for Curriculum



	The teachers' workload is within the maximum allowable teaching load.	
<i>Involvement with stakeholders</i>	The school builds a partnership with the community, especially science institutions, for the work immersion of students.	Copy of memorandum of agreement
	The teachers and administrators engage and involve parents in student development.	Copy of memorandum of understanding
	The school collaborates with Local Government Units (LGUs) and Non-Government Organizations (NGOs).	Copy of the minutes of the PTA meeting Documentations



Philippine Normal University
National Center for Teacher Education

Table 30. The Validated Proposed Training Matrix for STEM Teachers

Day	Module	Suggested Activities	Time Allotment	Specific Learning Goals	Modality
1	Lenses of STEAM Education: Theories and Practices	Lecture-Discussion	2 hours	To gain knowledge and understand the critical features of STEAM Education	Flexible (face to face, synchronous, asynchronous, or hybrid of mentioned techniques)
	The Validated STEAM Education Framework for SHS STEM Strand: Principles, Components, and Elements	Lecture-Discussion	2 hours	To know the salient features of the validated STEAM Education Framework for SHS STEM Strand	
		Group sharing	2 hours	To identify the key areas in the participants' school that need to be strengthened for STEAM Education	
2	From STEM to STEAM: Integration of Arts in STEM Subjects	Lecture-Discussion	2 hours	To incorporate art in topics or lessons on different subjects using the design thinking principle	
		Workshop (Empathy, Defining the Problem, Ideation, Prototype, Testing)	4 hours	To practice the design thinking principle such as empathy, defining the problem, ideation, prototype, and testing	
3	Innovative Pedagogies in STEAM Education	Lecture-Discussion	2 hours	To learn novel pedagogies that could be used in a STEAM classroom	
		Demonstration Teaching	2 hours	To demonstrate different STEAM teaching strategies	



Philippine Normal University
National Center for Teacher Education

		Group Sharing	2 hours	To share best practices of teachers for the students to express their creativity	
4	Designing STEAM Lessons and Activities: Context of Limited Materials and Lack of Laboratory Rooms	Lecture-Discussion	2 hours	To relate and connect different subject areas through creative STEAM lessons	Flexible (face to face, synchronous, asynchronous, or hybrid of mentioned techniques)
		Writing Workshop (development of lesson exemplars)	2 hours	To create authentic STEAM lessons despite limited materials and lack of laboratory classrooms	
		Presentation and critiquing of lesson exemplars	2 hours	To write, present, and critique lesson exemplars highlighting innovative STEAM curriculum	
5	Capacitating Educators in STEAM-related Skills	Lecture-Discussion	3 hours	To capacitate educators in the skills relevant to STEAM Education in terms of technological, research, communication, and social-emotional competencies	
	Designing Assessment in STEAM-based Curriculum	Lecture-Discussion	3 hours	To familiarize STEAM educators in the assessment tools and strategies used in STEAM Education and design an authentic assessment based on real-life and concrete experiences	
6	Safe STEAM Education Learning - Teaching Environment	Lecture-Discussion	2 hours	To define classrooms conducive for STEAM teaching and learning	



Philippine Normal University

National Center for Teacher Education

		Group Sharing	2 hours	To formulate effective methods in maintaining a safe learning space for students in a STEAM classroom	
	Stakeholders' Involvement in STEAM Curriculum: Support and Partnerships	Lecture-Discussion	2 hours	To recognize and employ effective strategies in establishing connections and linkages with different stakeholders	



Philippine Normal University
National Center for Teacher Education

Table 31. The Validated Proposed Training Matrix for STEM Administrators

Day	Module	Suggested Activities	Time Allotment	Specific Learning Goals	Modality
1	Lenses of STEAM Education: Theories and Practices	Lecture-Discussion	2 hours	To gain knowledge and understand the critical features of STEAM Education	Flexible (face to face, synchronous, asynchronous, or hybrid of mentioned techniques)
	The Validated STEAM Education Framework for SHS STEM Strand: Principles, Components, and Elements	Lecture-Discussion	2 hours	To know the salient features of the validated STEAM Education Framework for SHS STEM Strand	
		Group sharing	2 hours	To identify the key areas in the participants' school that need to be strengthened for STEAM Education	
2	From STEM to STEAM: Integration of Arts in STEM Subjects	Lecture-Discussion	2 hours	To incorporate art in topics or lessons on different subjects using the design thinking principle	
		Workshop (Empathy, Defining the Problem, Ideation, Prototype, Testing)	4 hours	To practice the design thinking principle such as empathy, defining the problem, ideation, prototype, and testing	
3	Innovative Pedagogies in STEAM Education	Lecture-Discussion	2 hours	To learn novel pedagogies that could be used in a STEAM classroom	
	Designing STEAM Lessons and Activities: Context of Limited Materials and Lack of Laboratory	Lecture-Discussion	2 hours	To relate and connect different subject areas through creative STEAM lessons	



Philippine Normal University
National Center for Teacher Education

	Rooms				
	Stakeholders' Involvement in STEAM Curriculum: Support and Partnerships	Lecture-Discussion	2 hours	To recognize and employ effective strategies in establishing connections and linkages with different stakeholders	
4	Capacitating Educators in STEAM-related Skills	Lecture-Discussion	3 hours	To capacitate educators in the skills relevant to STEAM Education in terms of technological, research, communication, and social-emotional competencies	Flexible (face to face, synchronous, or hybrid of mentioned techniques)
	Designing Assessment in STEAM-based Curriculum	Lecture-Discussion	3 hours	To familiarize STEAM educators in the assessment tools and strategies used in STEAM Education and design an authentic assessment based on real-life and concrete experiences	
5	Safe STEAM Education Learning - Teaching Environment	Lecture-Discussion	2 hours	To define classrooms conducive for STEAM teaching and learning	
		Group Sharing	1 hour	To formulate effective methods in maintaining a safe learning space for students in a STEAM classroom	
	STEAM Transformative Leadership: Sound Administration and Effective Management	Lecture-Discussion	2 hours	To equip STEM administrators' knowledge and skills in supervising STEAM Teachers	
		Sharing of Best Practices	1 hour	To recognize efficient management techniques in a STEAM environment	



Way Forward

Anchoring from the validation results of the framework and the training design and set of indicators and standards, the following items (Figure 44) are selected as the future endeavors for the developed STEAM Education Framework for Senior High School STEM Strand.

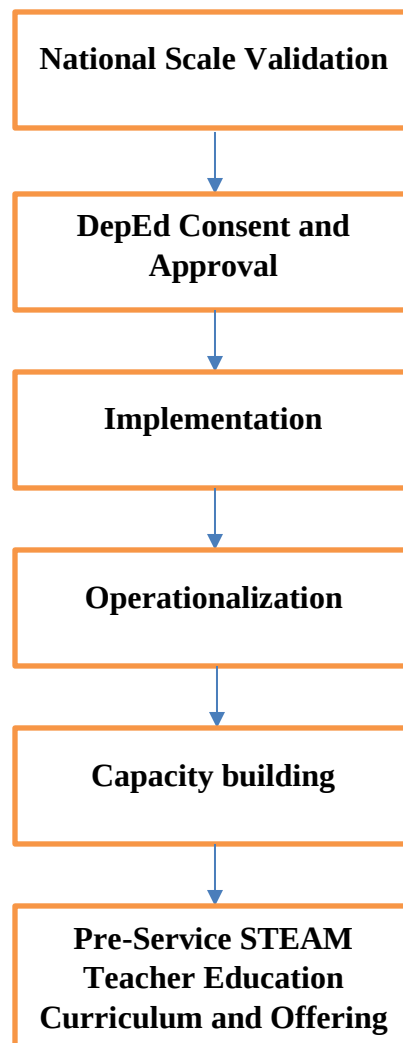


Figure 44. *Future endeavors for the validated framework*



Philippine Normal University National Center for Teacher Education

National Scale Validation

The framework was developed through a grounded theory approach that limits the participants and setting to Nueva Ecija. With these limitations, the developed framework may be confirmed with larger samples of participants who are not only STEM teachers and administrators from the province of Nueva Ecija but also from those who randomly represent the country's entire population. Retesting or revalidating the study using different approaches of grounded theory such as the traditional grounded theory of Glaser and Strauss (1967) or the constructivists grounded theory of Charmaz (2006) may also be done. To enrich the data and provide more information, quantitative or mixed-method may be utilized. Other subject teachers, especially Arts teachers, may serve as respondents in revalidating the framework at a national level.

Department of Education Consent and Approval

To have a greater impact, the authorities must scrutinize the validated framework. To do this, consent and approval of the Department of Education must be secured. The data that will be obtained from the national validation and the write-up of the pilot study will be given to DepEd for their validation purposes.

Implementation of the Framework, Training Design, and Standards and Indicators

An implementation may assure the effectiveness of the framework. Thus, it is valuable to implement the validated framework, standards and indicators, and training



Philippine Normal University National Center for Teacher Education

design in STEM Strand schools from different parts of the country to determine their effectiveness in a natural setting. The data gathered from the implementation will be used to refine the developed framework.

Policies and Guidelines on Operationalization

Refinement of STEM curriculum, arts integration, and reorientation and harmonization of policies are perceived by the participants to help implement STEAM education. These items are also considered salient standards in the framework. Thus, crafting policies and guidelines will aid the operationalization of the developed framework in the field.

Capacity building for teachers and administrators on STEAM Education

Support for the improvement of teachers and administrators in terms of qualifications, competencies, pedagogical characteristics, and assessment practices is warranted. Upon the approval of the policies and guidelines on the operationalization of the framework, in-service teaching capacity building and professional development for teachers and administrators on STEAM Education must be conducted. The training design proposed with the framework could serve as the baseline plan. Through this capacity building, the collaboration and promotion of STEAM disciplines may be instilled in the community. STEAM-related research undertakings can also be visualized through this training.



Philippine Normal University National Center for Teacher Education

Pre-Service STEAM Teacher Education Curriculum and Offering

The respondents in the study acknowledged the absence of training and experience on the integration of arts in the STEM Field, which caused their fear of implementing STEAM education. This may be attributed to their academic training during their pre-service. This problem can be solved if a dedicated undergraduate program focusing on STEAM Education is offered.

As new standards are implemented, and curriculum audits and fine-tunings are completed, it is critical to recognize the significance of ensuring teacher development and STEAM education quality. Thus, the alignment of teacher education curricula in consonance with the promotion of STEAM Education in the country is needed. DepEd and the Commission of Higher Education (CHED) may use the framework as a reference in the development of the program.



CHAPTER 4

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter, divided into four sections, presents the summary, conclusions, and recommendations based on the data gathered and analyzed. The first section contains the summary while the second section explains the salient findings of this research. Meanwhile, the third section discusses the conclusion of the study aligned with the research questions. Lastly, the fourth section provides recommendations to the beneficiaries of the research and suggestions for future researchers in conducting the same analysis. Generally, this chapter aims to present an extensive summary of what had been done, the significant findings and outputs, generalizations and other inferences, and the research recommendations.

Summary

STEAM education has been defined as the blending of the Arts field with STEM disciplines. This approach has not already been applied in the Philippines Senior High School curriculum. However, the absence of a concrete framework for implementation may only hamper the endeavor of having a STEAM curriculum in SHS. The lack of framework may only result in unorganized implementation. Thus, this study mainly focused on designing and developing a STEAM Education Framework for senior high school (SHS) STEM Strand. Three research questions were employed as directives of this research. The three main questions with sub-questions that gave the overall framework of



Philippine Normal University National Center for Teacher Education

the study are: (1) What are the needs and constructs of SHS STEM Strand from different types of high school in Nueva Ecija on the perspective of teachers and administrators in pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, among others for the implementation of STEAM Education? (2) How can these needs and constructs inform the design of a STEAM Education Framework for SHS STEM Strand? (3) What modifications are needed to improve the developed framework based on validation processes: (a) What inputs may be derived from experts? (b) What are the elements and processes of a training design that can be derived from the developed framework? (c) What are the indicators and standards for STEAM Education in SHS that can be derived from the framework?

The study employed the Strauss and Corbin (1990) grounded theory approach to answer the research questions. The participants of the study were 11 SHS teachers and 11 administrators from STEM Strand who were from different types of high school namely private schools with SHS, public schools with integrated JHS and SHS, public schools with stand-alone SHS, public Higher Education Institution (HEI) with SHS, and private HEI with SHS in Nueva Ecija. The participants were selected through stratified purposive and theoretical sampling. Interview guides or aide memoires were crafted and validated. The semi-structured interview guides serve as the sole source of data. The interview was conducted through online platforms such as Zoom, Google Meet, Cisco WebEx, and Microsoft Teams (MS Teams). The interviews were transcribed and translated. Field notes, memoing, and case summary through contact summary form were done to



Philippine Normal University National Center for Teacher Education

facilitate the qualitative analysis and to have a detailed and extensive data collection. Afterwards, interview data were coded in accordance with the proposed scheme of Strauss and Corbin (1998): open, axial, and selective coding. In addition, the constant comparison method, a concurrent data collection and analysis, was conducted along with the open and axial coding. Data validity was assessed through member checking, triangulation, intercoding, and checking of researcher's bias. Then, the framework was established and from this, a training design and set of standards and indicators were developed. A panel of experts validated the framework as well as the mentioned outputs through rounds of the Delphi technique.

Findings

Based on the result of the study, the following findings were drawn:

1. The interview questions on pedagogical character and traits of teachers revealed the participants' construct on the qualifications, qualities, and must-have skills of a teacher teaching in STEM Strand. In terms of curriculum, curriculum concepts as well-designed, congested, comprehensive, and ideal were noted by the participants. The participants also mentioned their needs as they said the lack of teaching and learning resources, availability of laboratory rooms, and limited learning materials such as equipment and chemical reagents. Furthermore, the interviewed participants observed the limited training provided when there is new science equipment in the school.



Philippine Normal University National Center for Teacher Education

2. The participants also shared their issues, such as having entrance exams on the STEM strand, students who transfer to other strands, the inclusion of other subjects, and the various schedule offerings of subjects in different schools. Interview questions on instruction and delivery resulted in the need to enhance STEM teachers' content and pedagogical knowledge and the understanding of the pedagogical strategies employed by STEM teachers. The participants also explained the importance of licensed teachers and their predicaments on having heavy workloads and misalignment of the subjects they handled with their specialization.
3. The interview questions on the feedback system expounded the STEM teachers' innovative assessment strategies and practical assessment tools. The administrators were able to impart their constructs on their leadership, management, support, and partnership with the stakeholders. In terms of the learning environment, the participants shared the need for students' safety and security. They emphasized the need for an environment free from discrimination and acknowledged diversity and inclusivity. The interview questions on institutional support established the needs for training, seminars, workshop, linkages with the community, parent collaboration, and support from Local Government Units (LGUs) and Non-governmental Organizations (NGOs).
4. Data analysis of the interview responses yielded 286 open codes, 41 axial codes (categories), and 11 selective codes (themes). The core categories or themes that emerged and were identified are *teacher's qualifications*, *competencies*,



Philippine Normal University National Center for Teacher Education

pedagogical characters, STEM curriculum refinement, discipline integration, administrator' leadership and management, student' skills, assessment practices, safe learning space, policy reorientation and harmonization, and partnership and support. The following details are for each theme.

- 4.1. Participants perceive teachers' qualifications as teachers must have specialization aligned with the subjects in the STEM Strand, having an advanced degree such as master's (MS/MA) and doctor's degree (PhD), teachers have specialized training on the subject one teaches, a passer of the Board of Licensure Examination for Professional Teachers (BLEPT), and have sufficient teaching experience.
- 4.2. The teacher competencies deemed important by the interviewed participants are subject-matter competency, lifelong learning competency, technological competency, research competency, communication competency, and emotional and social competencies.
- 4.3. Three pedagogical characters were deduced based on the pedagogy techniques employed by teachers, to wit: *communicating teacher*, *engaging teacher*, and *transforming teacher*. *Communicating Teachers* employs interactive pedagogy while *Engaging teachers* utilizes collaborative or cooperative pedagogy. Meanwhile, *Transforming teachers* uses reflective, critical, or creative pedagogy.



Philippine Normal University National Center for Teacher Education

- 4.4. Participants described the current STEM curriculum as *comprehensive yet congested, work-oriented yet very idealistic, and well-designed yet problematic*.
- 4.5. According to the participants, arts subjects must be integrated into the STEM disciplines to promote creativity from the students. The interviewed participants thought that character education subjects, arts, and other science-related courses are missing in the present curriculum since STEM is overly focused on content and very technical and mechanical in nature.
- 4.6. Administrator in the senior high school level manages the STEM Strand as stewards, managers, and teachers. In this light, the participants accentuated the role of administrators in the curriculum. Thus, administrators as transformative leaders provide managerial leadership, instructional leadership, strategic thinking innovation, stakeholder engagement, and personal excellence.
- 4.7. Teachers and administrators nurture the students to be creative persons, innovative individuals, critical thinkers, and reflective learners as revealed by the participants. The participants believe that being innovative, creative, critical, and reflective will make STEM students more holistically developed.
- 4.8. STEM teachers implement DepEd assessment strategies regardless of what type of school they come from. They claimed that formative and



Philippine Normal University National Center for Teacher Education

summative assessments based on the learning competencies, performance standards, and content standards set by DepEd are the general routine in their classes. They use reflective questions and authentic assessments like simulations, role-playing, and portfolio to promote creativity and innovation among STEM students. They are more familiar with traditional assessment than authentic assessment, which may be attributed to their lack of technological competency.

4.9. Safe learning space provides a secured environment that includes diversity and inclusivity, protection from violence both within and outside the school, and appropriate pedagogy and curriculum. Thus, participants believe that teachers and administrators must be vigilant with the environmental factors and classroom climate, especially teachers' classroom management, physical environment, and effective traits of teachers, as these factors tend to affect the holistic well-being of learners.

4.10. Certain policies in the STEM Curriculum need to be reoriented, changed, included or harmonized in order to streamline the implementation of STEAM Education. Concerns such as entrance examination, non-board passer teachers, STEM teachers with many or mismatched subjects, STEM Students switching to different strand and non-science courses, and the harmonization of scheduling of STEM subjects need to be addressed with new or modified policies.



Philippine Normal University National Center for Teacher Education

4.11. Parents and community, as well as the institution itself, are partners in education as emphasized by the participants. The involvement of them as stakeholders creates a fluidity of educational instruments for practical and conducive management. There are known benefits regarding parents and community participation, such as cooperation in curricula and education, good education commitment results, decision-making, and internalization of the school's connection to the people who can outspread those walls into the student's environment. Thus, there is no reason to exclude the stakeholders' engagement in implementing the curriculum because teachers, administrators, and other professional experts cannot replace the element of educational support by engaging internal and external stakeholders.

5. From the following themes, an emergent framework was developed. The framework is in a wheel-like diagram with a circular motion (cycle) in the outermost part of the figure. It consists of three inner circles and a cycle on the outside consisting of three arrows in a continuous motion. The arrows depict the parents, community, and institution's support and partnership while the outer circle contains the nine standards vital for implementing STEAM education. The next circle stands for the type of students envisioned by the teachers and administrators to produce. In contrast, the innermost circle depicts STEAM education as the central core of the framework.



Philippine Normal University National Center for Teacher Education

6. The emergent framework underwent three rounds of validation in the Delphi technique before a consensus of acceptance of the framework was attained. Two revisions of the framework were done incorporating the validators' suggestions solicited through an open-ended questionnaire. All the validators approved the revised framework regarding content and organization, relevance and usability, and aesthetics and presentation.
7. The validated framework highlights the different roles of stakeholders in implementing STEAM education in the country. The framework is in a wheel-like diagram with a circular motion (cycle) in the outermost part of the figure. It consists of four inner circles and a cycle on the outside consisting of three arrows which are in a continuous motion emphasizing the outcomes and the standards needed for STEAM Education in the country. The four inner circles depict the STEAM Education (innermost circle), the envisioned end-products (second innermost circle), the quality standards needed for the implementation (third innermost circle), and the stakeholders involved for each standard (outermost circle). The three arrows symbolize parental involvement, community partnership, and institutional support which are vital for the curriculum.
8. From the validated framework, a training design and set of indicators and standards were developed. The crafted standards and indicators aim to provide an objective way of measuring and demonstrating the success of the implementation of STEAM Education. On the other hand, a training design that considers content, training/learning objectives, delivery mode, audience and learning style, and the



Philippine Normal University National Center for Teacher Education

timeline was developed. A six-day training program for STEM teachers and a five-day training program for administrators were proposed using the training design. The training matrix for teachers comprises nine modules while for administrators, it comprises of ten modules. A maximum of six hours of participation per day is expected.

9. The training design and set of standards and indicators were validated by the same panel of experts who validated the framework. Two rounds of the Delphi technique were conducted before a consensus of acceptance of the training design and a set of indicators and standards was attained. Overall, the mentioned outputs received positive comments from the validators during the validation using an open-ended questionnaire. For the second validation involving questionnaire answerable in Likert scale, the validators strongly agree on all validation statements.

Conclusions

Based on the findings of this study, the following conclusions were formulated:

1. Exploration on the needs and constructs of SHS STEM Strand from different types of high school in Nueva Ecija on the lens of teachers and administrators in pedagogical character and traits of the teachers, curriculum, instruction and delivery, feedback system, learning environment, institutional support, among others for the implementation of STEAM Education yielded eleven themes namely *teacher's qualifications, competencies, pedagogical characters, STEM*



Philippine Normal University National Center for Teacher Education

curriculum refinement, discipline integration, administrator' leadership and management, student' skills, assessment practices, safe learning space, policy reorientation and harmonization, and partnership and support. These themes encompass the totality of perspectives for the current situation of STEM curriculum in the country.

2. A STEAM education framework for SHS STEM Strand was formulated from the mentioned themes and was validated. The validated framework is expected to help the Department of Education implement an effective STEAM education curriculum in the country.
3. The training design, indicators, and standards were sourced out from the validated framework as second-tier validation of the developed STEAM Education framework. The inputs derived from the experts helped improve and provide modifications for the framework and the mentioned outputs. The validated training design hopes to aid training implementers to ensure the future success of STEAM capacity building for SHS science teachers while the validated standards and indicators aims to serve as a future quality assurance mechanism for the STEAM curriculum in the country.



Philippine Normal University National Center for Teacher Education

Recommendations

Based on the findings and conclusions of this study, the following are recommended:

1. Internal and external stakeholders such as teachers, administrators, curriculum experts, policy makers, learners, parents, and the community should cooperate with each other to produce a holistic STEAM education curriculum.
2. Support for the improvement of teachers in terms of qualifications, competencies, pedagogical characteristics, and assessment practices is warranted. Refinement of STEM curriculum, arts integration, and reorientation and harmonization of policies will surely help the implementation of STEAM education. For students, having a safe learning space will aid them to express their creativity in a STEAM environment. The administrator's roles in terms of supervision, leadership, and management will complete the picture.
3. Future researchers may implement the validated framework, standards and indicators, and training design in a STEM Strand school to determine their effectiveness in a natural setting.
4. Future researchers may also confirm the developed framework with larger samples of participants who are not only STEM teachers and administrators from the province of Nueva Ecija but also from those who randomly represent the country's entire population.



Philippine Normal University National Center for Teacher Education

5. Future researchers may consider retesting or revalidating the study using different approaches of grounded theory such as the traditional grounded theory of Glaser and Strauss (1967) or the constructivists grounded theory of Charmaz (2006).
6. Future researchers may also use quantitative or mixed-methods to enrich the data and provide more information not taken through the grounded theory approach.
7. Future researchers may consider other subject teachers, especially Arts teachers as respondents in revalidating the framework.



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APPENDICES



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APPENDIX A

**LIST OF SENIOR HIGH SCHOOLS OFFERING STEM STRAND IN NUEVA
ECIJA**

Division of Cabanatuan City

Public HEI with SHS STEM Strand	1
Nueva Ecija University of Science and Tecnology	
Private HEI with SHS STEM Strand	10
ABE International College of Business and Economics-Cabanatuan City	
AMA Computer College-Cabanatuan City, Inc.	
Coll. of The Immaculate Conception	
Good Samaritan Colleges	
M.V. Gallego Foundation Colleges	
Midway Colleges, Inc.	
Nueva Ecija Doctors' College Inc.	
PHINMA Araullo University	
PHINMA-Araullo University-South Campus	
Wesleyan University-Philippines	
Private Schools with SHS STEM Strand	0
<NONE>	
DepEd Stand Alone SHS with STEM Strand	1
Cabanatuan City Senior High School	
DepEd integrated SHS with STEM Strand	5
Camp Tinio National High School	
Honorato C. Perez, Sr. Mem. Sci. HS	
Marciano del Rosario Memorial NHS	
Mayapyap National High School	
San Josef National High School	



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Division of Gapan City

Public HEI with SHS STEM Strand	0
<NONE>	
Private HEI with SHS STEM Strand	2
Divina Pastora College	
ACLC College of Gapan, Nueva Ecija	
Private Schools with SHS STEM Strand	1
Village Montessori School – Gapan	
DepEd Stand Alone SHS with STEM Strand	0
<NONE>	
DepEd integrated SHS with STEM Strand	3
Juan R. Liwag Memorial National High School	
Sta Cruz National High School	
San Roque National High School	

Division of Science City of Muñoz

Public HEI with SHS STEM Strand	1
Central Luzon State University Science High School	
Private HEI with SHS STEM Strand	0
<NONE>	
Private Schools with SHS STEM Strand	1
San Sebastian School	
DepEd Stand Alone SHS with STEM Strand	1
Munoz National High School - Senior High School	
DepEd integrated SHS with STEM Strand	0
<NONE>	



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Division of Nueva Ecija

Public HEI with SHS STEM Strand	0
<NONE>	
Private HEI with SHS STEM Strand	6
Our Lady of the Sacred Heart College of Guimba, Inc. (Guimba)	
General de Jesus College (San Isidro)	
Holy Rosary Colleges Foundation (San Isidro)	
Dr. Gloria D. Lacson Foundation Colleges, Inc. (San Leonardo)	
Holy Cross College - Nueva Ecija (Santa Rosa)	
REH Montessori College, Inc (Talavera)	
Private Schools with SHS STEM Strand	16
Bongabon Essential School (Bongabon)	
St. Francis of Assisi Diocesan School (Bongabon)	
Saint John Nepomucene Parochial School (Cabiao)	
St. Pius X Institute (Cuyapo)	
Gabaldon Essential Academy (Gabaldon)	
Bonifacio Luz Natividad Foundation, Inc. (Guimba)	
San Agustin Diocesan Academy (Jaen)	
Charles Angel Montessori School (Llanera)	
Saint Andrew's School of Pantabangan Inc. (Pantabangan)	
Solomon's Excellence Academy School, Inc. (Quezon)	
J. Victoria Montessori School (San Isidro)	
Lasaltech Academy (San Leonardo)	
St. Rose of Lima Catholic School (Santa Rosa)	
Liceo de Christ the King, Inc. (Talugtug)	
Vincentian Catholic Academy (Zaragoza)	
Holy Family Academy of Quezon, Nueva Ecija, Inc. (Quezon)	
DepEd Stand Alone SHS with STEM Strand	3
Nueva Ecija High School - Senior High School (Cabanatuan)	
Bongabon NHS - Senior High School (Bongabon)	
Cabiao NHS - Senior High School (Cabiao)	
DepEd integrated SHS with STEM Strand	20
Aliaga National NHS (Aliaga)	
Carranglan NHS (Carranglan)	
Dr. Ramon de Santos National High School (Cuyapo)	



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General Tinio National High School (General Tinio)	
Bartolome R Sangalang National High School (Guimba)	
Doña Juana Chioco National High School (Lupao)	
Palayan City National High School (Palayan)	
Penaranda National High School (Penaranda)	
Rizal National High School (Rizal)	
Julia Ortiz Luiz National High School (Santo Domingo)	
San Ricardo National High School (Talavera)	
Talavera National High School (Talavera)	
Zaragoza National High School (Zaragoza)	
Eduardo L. Joson Memorial High School (Cuyapo)	
Sto. Domingo National Trade School (Santo Domingo)	
Gabaldon Vocational Agricultural High School (Gabaldon)	
General Mamerto Natividad National High School (Gen. Natividad)	
Sta. Rosa National High School (Sta. Rosa)	
Putlod-San Jose National High School (Jaen)	
Mambangnan National High School (San Leonardo)	

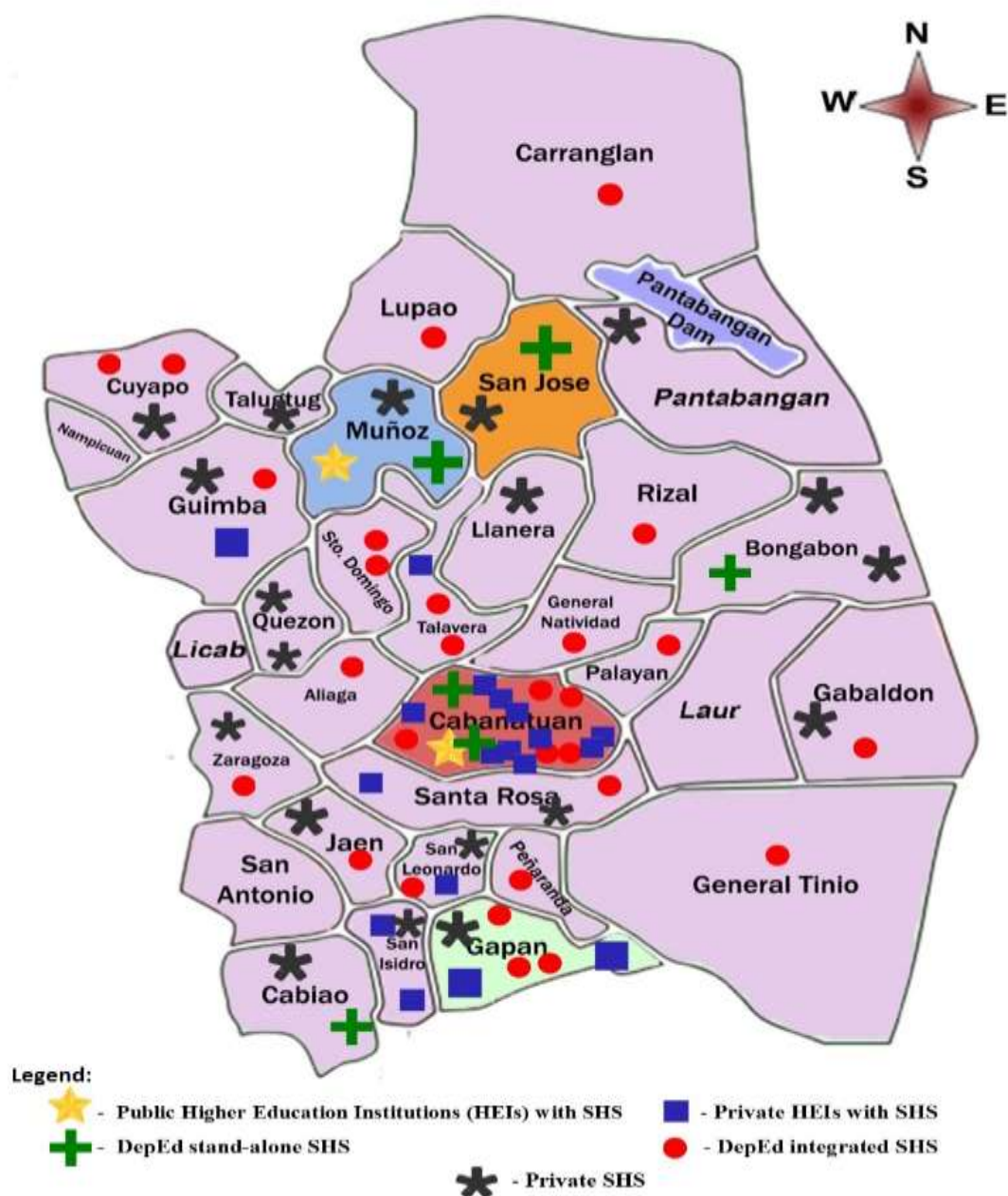
Division of San Jose City

Public HEI with SHS STEM Strand	0
<NONE>	
Private HEI with SHS STEM Strand	0
<NONE>	
Private Schools with SHS STEM Strand	1
St. Joseph School of San Jose City, Nueva Ecija, Inc.	
DepEd Stand Alone SHS with STEM Strand	1
San Jose City National High School - Senior High School	
DepEd integrated SHS with STEM Strand	0
<NONE>	



APPENDIX B

GEOGRAPHICAL DISTRIBUTION OF SHS OFFERING STEM STRAND IN NUEVA ECIJA





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APPENDIX C

ETHICAL CLEARANCE FROM THE PNU RESEARCH ETHICS COMMITTEE

 PHILIPPINE NORMAL UNIVERSITY The National Center for Teacher Education Taft Ave. Cor. Ayala Blvd., Ermita, Manila 1000 Philippines Telephone: +63-2-317-1768 loc. 750/751 opr@pnu.edu.ph www.pnu.edu.ph	Index No.	PNU-MN-2016-EPR-FM-016	
	Issue No.	01	
	Rev. No.	01	
	Date:	09-24-2018	
	Page	1 of 1	
EPRDC	CLEARANCE TO PROCEED	QAC No.	CC-09242018-023

BASIC INFORMATION

REC Code:	08152020-018
Research Proposal Title:	STEAM Education Framework for Senior High School STEM Strand
Researcher / Project Leader and Designation/Affiliation:	Lexter R. Natividad

The following items [✓] have been received and reviewed in connection with the above study to be conducted by the above researcher.

- [✓] Research Proposal in prescribed format
- [✓] Informed Consent Form/s /Assent Form
- [✓] Data Collection Tools

and hereby approved:

- [✓] To proceed to the validation of the data gathering tools
- [✓] To proceed to data collection, organization and write-up

Date of Issuance: **August 15, 2020**

Dr. TERESITA T. RUNGDUIN (SGD)
Secretary
Research Ethics Committee

Dr. RENE R. BELECINA (SGD)
Chair
Research Ethics Committee

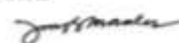
(All documents without the PNU QM Stamp or Control Identifier are uncontrolled)



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APPENDIX D

LETTER REQUEST FOR THE DEPED REGION III APPROVAL TO CONDUCT
STUDY IN NUEVA ECIJA

	Philippine Normal University <i>The National Center for Teacher Education</i> College of Graduate Studies and Teacher Education Research Pedro Orata Hall, Room 304 B, Taft Avenue, Manila	
August 20, 2020		
Dr. NICOLAS T. CAPULONG OIC- Regional Director DepEd Region III Maimpis, City of San Fernando, Pampanga		
Dear Dr. Capulong:		
Greetings from the Philippine Normal University!		
I am a PhD Science Education Student at the Philippine Normal University, Taft Ave., Manila and currently working on my dissertation titled, "<i>STEAM Education Framework for Senior High School STEM Strand</i>." The goal of the study is to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Sequentially, the study hopes to produce training design, indicators and standards as validation products of the framework.		
The study will employ Strauss and Corbin (1990) grounded theory approach and the SHS science teachers in STEM Strand and their corresponding administrator or principal are the target participants. To have representative participants for each type of senior high schools offering STEM strand in Nueva Ecija, stratified purposive sampling will be used. Thus, participants will come from SHS offering STEM-academic strand in Nueva Ecija categorized into five to wit: (a) Public Higher Education Institutions (HEIs) with SHS, (b) Private HEIs with SHS, (c) Department of Education (DepEd) with stand-alone SHS, (d) DEPED school with integrated JHS and SHS, and (e) Private SHS.		
It is in this regard that I kindly request permission to conduct my dissertation in Nueva Ecija. Also, I kindly request for a list of schools offering STEM-academic strand in each category in Nueva Ecija (Division of Gapan, Division of Nueva Ecija, Division of San Jose City, Division of Science City of Munoz, and Division of Cabanatuan City).		
Attached are the requirements stated in DepEd Regional Memorandum No. 228 s. 2020 titled "Policy Guidelines on the Adherence to Ethical Research Principles and Responsibilities in Studies Involving Teaching, Teaching-Related, Non-Teaching Personnel and Learners" for your perusal.		
It is with high hope that I would merit your support in this endeavor through the approval of my requests. Thank you very much and more power.		
Very truly yours,		
 Dexter R. Natividad PhD Science Education Student		
Noted:		
 Marie Paz E. Morales, PhD Adviser		



Philippine Normal University
National Center for Teacher Education

APPENDIX E

LETTER REPLY OF DEPED REGION III REGARDING APPROVAL TO
CONDUCT STUDY IN NUEVA ECIJA


Republic of the Philippines
Department of Education
REGION III-CENTRAL LUZON

RECEIVED - REGIONAL OFFICE
SEP 22 2020

September 16, 2020

LEXTER R. NATIVIDAD
Philippine Normal University
College of Graduates Studies and Teacher Education Research
Pedro Orata Hall, Room 304 B, Taft Avenue, Manila

Dear Mr. Natividad:

Relative to your request to conduct research on your dissertation entitled "STEAM Education Framework for Senior High School STEM Strand," kindly submit the requirements stated in the attached DepEd Regional Memorandum No. 228, s. 2020 entitled "Policy Guidelines on the Adherence to Ethical Research Principles and Responsibilities in Studies Involving Teaching, Teaching-Related, Non-Teaching Personnel and Learners" under paragraph 4 before this Office can take action to your request. Thank you.

Very truly yours,


NICOLAS T. CAPUDONG, Ph.D., CESO V
Director III
Officer-In-Charge
Office of the Regional Director

Incl.: As stated.

PPRD02/16ra25

2617

 Address: Matalino St. D.M. Government Center, Maimpis, City of San Fernando (P)
Telephone Number: (045) 598-8580 to 89; Email Address: region3@deped.gov.ph

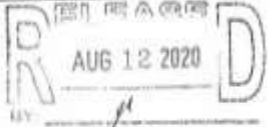

Certificate No. AIA17-0077



Philippine Normal University
National Center for Teacher Education

APPENDIX F

DEPED REGION 3 MEMORANDUM NO. 228 s. 2020 (*Policy Guidelines on the Adherence to Ethical Research Principles and Responsibilities in Studies Involving Teaching, Teaching-Related, Non-Teaching Personnel and Learners*)

 Republic of the Philippines Department of Education REGION III-CENTRAL LUZON		REGION III - RECORDS SECTION 
REGIONAL MEMORANDUM No. 228, s. 2020		
POLICY GUIDELINES ON THE ADHERENCE TO ETHICAL RESEARCH PRINCIPLES AND RESPONSIBILITIES IN STUDIES INVOLVING TEACHING, TEACHING- RELATED, NON-TEACHING PERSONNEL AND LEARNERS		
To: Schools Division Superintendents		
1. In accordance with DepEd Order No. 16 s. 2017 entitled Research Management Guidelines, Republic Act No. 10173 known as Data Privacy Act of 2012, and DepEd Order No. 40 s. 2012 entitled Child Protection Policy, DepEd Regional Office III hereby issues the policy guidelines on the adherence to ethical research principles and responsibilities in studies involving teaching, teaching-related, non-teaching personnel, and learners. The policy aims to strengthen the adherence to the principles and responsibilities for the ethical conduct of research at the regional, division, and school levels. It covers research studies funded by the Policy Research Program Fund (PRPF) and non-PRPF studies, including those studies for degree requirements in which permit to conduct the study is also requested. 2. Under Paragraph VI, Special Provisions (C) Research Ethics of DepEd Order No. 16 s. 2017, education research, in particular, heavily focuses on learners and their immediate environment. Thus, researchers shall observe the highest ethical standards. Similarly, research managers shall uphold ethical principles in evaluating and implementing research proposals to protect our learners and communities. This includes ensuring confidentiality in handling data of respondents and providing consent forms where necessary. In the interim, researchers will refer to the DepEd Child Protection Policy (DepEd Order No. 40 s. 2012) as a reference for interacting with learners. Further, for research that will involve I.P. learners, ICCs, IKPs, and ILSs, researchers will adhere to the rights-based approach and principles of inclusion, participation, and empowerment as stipulated in the National IPed Policy Framework (DepEd Order No. 62 s. 2011). 3. Meanwhile, the strict implementation of public health measures due to the Covid-19 Pandemic brings challenges in data collection to researchers. However, the same ethical principles for face to face data collection should be observed during remote data collection in terms of minimizing the risk of harm, obtaining informed consent and assent, protecting anonymity and confidentiality, avoiding deceptive practices and providing the right to withdraw.		
	Address: Matalino St. D.M. Government Center, Maimpis, City of San Fernando (P) Telephone Number: (045) 598-8580 to 89; Email Address: region3@deped.gov.ph	
	 Certificate No. AUK17-0077	



Philippine Normal University

National Center for Teacher Education



Republic of the Philippines
Department of Education
REGION III-CENTRAL LUZON

- 3.1 In surveys where an email list is acquired, the researcher should give a clear statement of the source of the email addresses and ensure that the individuals listed have prior consent before to be contacted in the future for any research purposes;
- 3.2 Informed consent and assent should be obtained from the participants before the conduct of the study. Participants should be made to understand what the goal of the research is and what they agree to do, the potential risks (e.g., limits to confidentiality) and benefits of taking part, and details of alternative options that may benefit them. Participants should have the option to ask questions and should be made to understand that participation is voluntary and that they have the right to withdraw at any time. Further, informed consent and assent forms should be written in plain language participants understand and should be signed by the participants. Misleading or deceptive statements should be avoided;
- 3.3 Researchers should be especially sensitive to the need to consider, respect and safeguard the wellbeing of particularly vulnerable participants of research including but not limited to children; those with physiological/psychological impairments; those dependant on the protection or in the care of others and those with limited knowledge of the language in which research is conducted;
- 3.4 Personal information of participants should not be sought from without their prior consent. The anonymity of participants should be maintained, and the researcher should ensure that data are not used for subsequent non-research purposes. Personally identifiable data and other research-related data should be kept, secured and stored separately;
- 3.5 Participants should be informed about the duration of the survey and should be given links to data protection, privacy policy, cookie policy statements, or information about the use of the software at the beginning of the survey, which should be available in simple language.
- 3.6 Researchers should obtain permission from the participants before recording their voices or images through informed consent;
- 3.7 Researchers should ensure the confidentiality of data and privacy of participants at all stages of the process: during all interactions with the participants and when the data is transmitted and stored and destroyed and;
- 3.8 Participants should be given entitlement to ask the researcher to delete their records, and the researcher should conform to such requests where reasonable.



Address: Matalino St, D.M. Government Center, Maimpis, City of San Fernando (P)
Telephone Number: (045) 598-8580 to 89; Email Address: region3@deped.gov.ph





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National Center for Teacher Education



Republic of the Philippines
Department of Education
REGION III-CENTRAL LUZON

4. Further in securing a permit to conduct research at the regional (a study involving two (2) or more Schools Division Offices) and division levels, the following should be attached to the **letter of request prior to the approval**: This is to safeguard ethical principles in research such as respect for persons and their welfare.
 - 4.1 Endorsement from the College/University
 - 4.2 Copy of Approval of the College/University Research Ethics Review Committee
 - 4.3 Instrument (Survey/Interview Guide)
 - 4.4 Copy of Data Collection, Security, Storage, Transfer, Destruction Procedures (details on how participants will be made aware of the survey online, measures to safeguard data at the site of data collection, measures to protect the privacy and confidentiality of participants, duration/period data will be stored online, measures on how the data will be transferred and destroyed after the study has been completed, measures on how to rectify and contain potential damage from breaches of confidentiality/security)
 - 4.5 Informed Consent Form
 - 4.6 Assent Form (in case the study involves learners below 18 years old)
 - 4.7 Informed Consent Form for Recording Interview (in case interview is a part of data gathering procedure)
5. Policy, Planning and Research Division (PPRD), in close collaboration with Quality Assurance Division (QAD) in the Regional Office and the School Governance and Operations Division (SGOD), shall conduct an annual review of the effectiveness and efficiency of the policy in achieving its objectives. Feedback from the M & E shall be reported during the Division Monitoring, Evaluation, and Adjustment (DMEA).
6. Immediate dissemination and compliance with this Memorandum is directed.


NICOLAS T. CAPULONG, PhD. CESO V
Director III
Officer-In-Charge
Office of the Regional Director

revmo/pprd05

References:

Republic Act No. 10173
DepEd Order 16, s. 2017
DepEd Order 40 s. 2012
DepEd Order 62 s. 2011
2017 American Psychological Association
Ethical Principles of Psychologists and Code of Conduct



Address: Matalino St. D.M. Government Center, Maimpis, City of San Fernando (P)
Telephone Number: (045) 598-8580 to 89; Email Address: region3@deped.gov.ph





Philippine Normal University
National Center for Teacher Education

APPENDIX G

ENDORSEMENT FROM THE PHILIPPINE NORMAL UNIVERSITY



Philippine Normal University
The National Center for Teacher Education
Graduate Research office
Pedro Orata Hall, Room 304 B, Taft Avenue, Manila



September 22, 2020

Dr. NICOLAS T. CAPULONG
OIC- Regional Director
DepEd Region III
Maimpis, City of San Fernando, Pampanga

Dear **Dr. Capulong**:

Greetings from the Philippine Normal University!

This is to respectfully endorse for your favorable action the letter-request of Mr. Lexter R. Natividad to conduct his dissertation in Nueva Ecija DepEd Senior High Schools and his request for the list of SHS offering STEM Strand in the Division of San Jose City, Division of Munoz, Division of Cabanatuan City, Division of Gapan City, and Division of Nueva Ecija.

His study was already approved by the University Research Ethics Review Committee as attached in his letter.

Thank you very much for your continued support.

Very truly yours,


Arlyne C. Marasigan, PhD
Director, PNU Graduate Research Office



Philippine Normal University
National Center for Teacher Education

APPENDIX H

APPROVAL OF DEPED REGION III OFFICE ON THE CONDUCT OF THE
STUDY IN NUEVA ECIJA

10


Republic of the Philippines
Department of Education
REGION III-CENTRAL LUZON

Nov 24 2020
R E C E I V E D
BY: *[Signature]*

1st Endorsement
November 18, 2020

Respectfully returned to **Mr. Lexter R. Natividad**, Researcher,
Philippine Normal University, Taft Avenue, Manila, the approved request to
conduct his study entitled "STEAM Education Framework for Senior High
School STEM Strand," provided that the participants will voluntarily
participate in the study and that the following shall be observed entirely
during the period of the study: non-utilization of government funds and
stationeries, no disruption of classes, and complete adherence to ethical
research principles and responsibilities. Please note that failure to comply
with the conditions stated will result in withdrawal of approval to conduct the
study. Attached is the list of schools offering STEM –academic strand in each
category in Nueva Ecija.

MAY B. ECLAR, PhD, CESO V
[Signature]
Regional Director

Incl.: As stated.
PPED02-1940019


Address: Matalino St. D.M. Government Center, Maimpis, City of San Fernando (P)
Telephone Number: (045) 598-8580 to 89; Email Address: region3@deped.gov.ph


Certificate No. AIA17-02



Philippine Normal University

National Center for Teacher Education

POLICY, PLANNING AND RESEARCH DIVISION

Name of Researcher: Lexter R. Natividad

School: Philippine Normal University

Title of Research: STEAM Education Framework for Senior High School STEM Strand

Required Attachments

(Based on R.M. 228, s. 2020)

- ☒ 1. Endorsement from the College/University
- ☒ 2. Copy of Approval of the College/University Research Ethics Review Committee
- ☒ 3. Instrument (Survey/Interview Guide)
- ☒ 4. Copy of Data Collection, Security, Storage, Transfer, Destruction Procedures (details on how participants will be made aware of the survey online, measures to safeguard data at the site of data collection, measures to protect the privacy and confidentiality of participants, duration/period data will be restored online, measures on how the data will be transferred and destroyed after the study has been completed, measures on how to rectify and contain potential damage from breaches of confidentiality/security)
- ☒ 5. Informed Consent Form
- ☒ 6. Assent Form (in case the study involves learners below 18 years old)
- ☒ 7. Informed Consent Form for Recording Interview (in case interview is a part of data gathering procedure)

Approved:

MATROSE P. GALARION, Ph.D.

OIC-Policy, Planning and Research Division



Philippine Normal University National Center for Teacher Education



DEPARTMENT OF EDUCATION ENHANCED BASIC EDUCATION INFORMATION SYSTEM Total Enrollment in Public Senior High Schools School Year: 2019 - 2020												
Aggregated by: Legislative Filtered by: Region III												
ID	School Name	Region	Province	Municipality	Division	School Type	Grade 11 STEM		Grade 12 STEM		Grade 11 & 12 Grand Total	
							Male	Female	Male	Female	Total	
TOTAL							524	597	1,121	459	432	891
Region: Region III												
Province/City: NUEVA ECUIA												
Legislative District: 1ST DISTRICT												
TOTAL							226	244	470	193	210	403
300783	Allaga National High School	Region III	NUEVA ECUIA	ALUAGA	Nueva Ecija	School with no Annexes	19	19	38	16	15	31
300803	Dr. Ramon de Santos NHS	Region III	NUEVA ECUIA	CUYAPO	Nueva Ecija	School with no Annexes	24	17	41	25	20	45
300809	Bartolome R Sangalang National High School	Region III	NUEVA ECUIA	GUIMBA	Nueva Ecija	Mother school	19	31	50	26	24	50
300804	Eduardo L. Josen Mem. HS	Region III	NUEVA ECUIA	QUEZON	Nueva Ecija	School with no Annexes	14	25	39	13	9	22
300814	Julia Ortiz Lutz NHS	Region III	NUEVA ECUIA	SANTO DOMINGO	Nueva Ecija	School with no Annexes	26	19	45	11	16	27
300857	Sio. Domingo NTS	Region III	NUEVA ECUIA	SANTO DOMINGO	Nueva Ecija	School with no Annexes	34	51	85	17	25	42
300850	San Ricardo NHS	Region III	NUEVA ECUIA	TALAVERA	Nueva Ecija	School with no Annexes	30	20	50	17	18	35
300864	TALAVERA NATIONAL HIGH SCHOOL	Region III	NUEVA ECUIA	TALAVERA	Nueva Ecija	School with no Annexes	47	40	87	42	51	93
300871	ZARAGOZA NATIONAL HIGH SCHOOL	Region III	NUEVA ECUIA	ZARAGOZA	Nueva Ecija	Mother school	13	22	35	26	32	58
Region: Region III												
Province/City: NUEVA ECUIA												
Legislative District: 2nd District												
TOTAL							46	54	100	69	38	107
300802	Dola Juana Choco National High School	Region III	NUEVA ECUIA	LUPAO	Nueva Ecija	School with no Annexes	15	22	37	25	15	40
300841	Rizal NHS	Region III	NUEVA ECUIA	RIZAL	Nueva Ecija	School with no Annexes	31	32	63	44	23	67
												130



Philippine Normal University

National Center for Teacher Education



ID	School Name	Region	Province	Municipality	Division	School Type	Grade 11 STEM		Grade 12 STEM		11 & 12 Grand Total	
							Male	Female	Male	Female	Total	Total
Region: Region III												
Province/City: NUEVA ECUIA												
Legislative District: 3RD District												
TOTAL							140	171	311	94	89	494
300826	Nueva Ecija NHS	Region III	NUEVA ECUIA	CABANATUAN CITY	Nueva Ecija	School with no Annexes	42	57	99	41	35	175
300790	Bongabon NHS	Region III	NUEVA ECUIA	BONGABON	Nueva Ecija	School with no Annexes	44	51	95	33	26	154
300805	Gabalbon Voc'l. Agrtc. HS	Region III	NUEVA ECUIA	GABALDON (BITULOK & SABANI)	Nueva Ecija	School with no Annexes	11	11	22	0	0	22
300862	Gen. Mamerto Natividad National HS	Region III	NUEVA ECUIA	GENERAL MANMERTO	Nueva Ecija	School with no Annexes	8	8	16	4	6	26
300828	Palayan City National High School	Region III	NUEVA ECUIA	NATIVIDAO (PALAYAN CITY [Capita])	Nueva Ecija	School with no Annexes	26	31	57	11	20	88
306801	SANTA ROSA NATIONAL HIGH SCHOOL	Region III	NUEVA ECUIA	SANTA ROSA	Nueva Ecija	School with no Annexes	9	13	22	5	2	29
Region: Region III												
Province/City: NUEVA ECUIA												
Legislative District: 4TH District												
TOTAL							112	126	240	103	95	438
300792	Cabiao National High School	Region III	NUEVA ECUIA	CABAO	Nueva Ecija	Mother school	17	19	36	27	30	93
300808	General Tinio NHS	Region III	NUEVA ECUIA	GENERAL TINIO (PAPAYA)	Nueva Ecija	School with no Annexes	39	56	95	44	32	171
300835	Pulod-San Jose NHS	Region III	NUEVA ECUIA	JAEN	Nueva Ecija	Mother school	19	11	30	8	7	45
300832	Peñaranda National High School	Region III	NUEVA ECUIA	POÑARANDA	Nueva Ecija	School with no Annexes	35	38	73	18	21	112
300821	Mambangan NHS	Region III	NUEVA ECUIA	SAN LEONARDO	Nueva Ecija	School with no Annexes	2	4	6	6	5	17



Philippine Normal University

National Center for Teacher Education



DEPARTMENT OF EDUCATION													
ENHANCED BASIC EDUCATION INFORMATION SYSTEM													
Total Enrollment in Public Senior High Schools													
School Year : 2019 - 2020													
Aggregated by: Legislative													
Filtered by: Region III													
ID	School Name	Region	Province	Municipality	Division	School Type	Grade 11 STEM		Grade 12 STEM		Grade 11 & 12 Grand Total		
							Male	Female	Male	Female	Total		
Region: Region III													
Province/City: CABANATUAN CITY													
Legislative District: 3RD DISTRICT													
TOTAL							202	234	436	129	157	286	722
301044	Honorato C. Perez, Sr. Mem. Sch. HS	Region III	NUEVA ECJIA	CABANATUAN CITY	Cabanatuan City	School with no Annexes	64	103	167	99	123	222	389
305633	Cabanatuan City Senior High School	Region III	NUEVA ECJIA	CABANATUAN CITY	Cabanatuan City	School with no Annexes	86	76	162	0	0	0	162
301048	San Josef National High School	Region III	NUEVA ECJIA	CABANATUAN CITY	Cabanatuan City	School with no Annexes	8	12	20	0	0	0	20
301046	Mayasrap National High School	Region III	NUEVA ECJIA	CABANATUAN CITY	Cabanatuan City	School with no Annexes	8	10	18	0	0	0	18
301047	Marciano del Rosario Memorial NHS	Region III	NUEVA ECJIA	CABANATUAN CITY	Cabanatuan City	School with no Annexes	11	19	30	17	11	28	58
301045	Cimp Tinio National High School	Region III	NUEVA ECJIA	CABANATUAN CITY	Cabanatuan City	School with no Annexes	25	14	39	13	23	36	75



Philippine Normal University

National Center for Teacher Education



DEPARTMENT OF EDUCATION													
ENHANCED BASIC EDUCATION INFORMATION SYSTEM													
Total Enrollment in Public Senior High Schools													
School Year : 2019 - 2020													
Aggregated by: Legislative													
Filtered by: Region III													
ID	School Name	Region	Province	Municipality	Division	School Type	Grade 11 STEM		Grade 12 STEM		Grade 11 & 12		
							Male	Female	Male	Female	Total	Total	
Region: Region III													
Province/City: GAPAN CITY													
Legislative District: 4TH DISTRICT													
TOTAL							110	105	215	87	70	157	372
300813	Sta. Cruz NHS	Region III	NUEVA ECJA	CITY OF GAPAN	Gapan City	School with no Annexes	13	7	20	5	10	15	35
300812	Juan R. Liwag Mem. NHS	Region III	NUEVA ECJA	CITY OF GAPAN	Gapan City	School with no Annexes	82	78	160	69	50	119	279
300851	San Roque NHS	Region III	NUEVA ECJA	CITY OF GAPAN	Gapan City	School with no Annexes	15	20	35	13	10	23	58



Philippine Normal University

National Center for Teacher Education



Republic of the Philippines
Department of Education
REGION III-CENTRAL LUZON

DEPARTMENT OF EDUCATION														
ENHANCED BASIC EDUCATION INFORMATION SYSTEM														
Total Enrollment in Public Senior High Schools														
School Year : 2019 - 2020														
Aggregated by: Legislative														
Filtered by: Region III														
ID	School Name	Region	Province	Municipality	Division	School Type	Grade 11 STEM		Grade 12 STEM		Grade 11 & 12			
							Male	Female	Male	Female	Total	Total		
Region: Region III														
Province/City: MUNOZ SCIENCE CITY														
Legislative District: 1ST DISTRICT														
TOTAL							50	46	96	26	36	62	158	
300824	Munoz National HS-Main	Region III	NUEVA ECUA	MUNOZ	SCIENCE CITY OF MUNOZ	Munoz Science City	Mother school	50	46	96	26	36	62	158



Philippine Normal University

National Center for Teacher Education



Republic of the Philippines
Department of Education
 REGION III-CENTRAL LUZON

DEPARTMENT OF EDUCATION												
ENHANCED BASIC EDUCATION INFORMATION SYSTEM												
Total Enrollment in Public Senior High Schools												
School Year : 2019 - 2020												
Aggregated by: Legislative												
Filtered by: Region III												
ID	School Name	Region	Province	Municipality	Division	School Type	Grade 11 STEM		Grade 12 STEM		Grade 11 & 12	
							Male	Female	Male	Female	Total	Grand Total
Region: Region III												
Province/City: SAN JOSE CITY												
Legislative District: 2ND DISTRICT												
TOTAL												
	San Jose City National High School						89	80	169	37	42	248
	(formerly Constancio Padilla National High School)											
3008000	School	Region III	NUEVA ECJIA	SAN JOSE CITY	San Jose City	Mother school	89	80	169	37	42	248



Philippine Normal University
National Center for Teacher Education

APPENDIX I

SAMPLE LETTER TO SCHOOL PRINCIPAL



Philippine Normal University
The National Center for Teacher Education
College of Graduate Studies and Teacher Education
Research
Pedro Orata Hall, Room 304 B, Taft Avenue, Manila



December 7, 2020

Ms. [REDACTED]
Principal
[REDACTED]
San Jose City, Nueva Ecija

Dear Ms. [REDACTED]:

Greetings from the Philippine Normal University!

I am a PhD Science Education Student at the Philippine Normal University, Taft Ave., Manila and currently working on my dissertation titled, "*STEAM Education Framework for Senior High School STEM Strand*." The goal of the study is to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Sequentially, the study hopes to produce a training design, a set of indicators and standards as validation products of the framework. The study will employ Strauss and Corbin (1990) grounded theory approach and the SHS science teachers in STEM Strand and their corresponding administrator are the target participants.

In this regard, I respectfully request your good office to allow **Ms. [REDACTED]** (SHS Coordinator) and **Ms. [REDACTED]** (STEM Teacher) to be interviewed on their experience and perspective in STEM Strand.

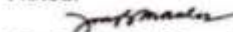
Attached herewith are the approval of the PNU ethics committee and DepEd Regional Office on the conduct of my study and the informed consent form where all the details of the study are explained. For queries regarding the study, you may please reach me through natividad.lr@pnu.edu.ph or at my mobile no. 09066760876.

It is with high hope that I would merit your support in this endeavor. Thank you very much and more power.

Very truly yours,


Dexter R. Natividad
PhD Science Education Student

Noted:


Marie Paz E. Morales, PhD
Adviser

RECEIVED
[REDACTED]
December 14, 2020



Philippine Normal University
National Center for Teacher Education

APPENDIX J

SAMPLE APPROVED LETTER TO HEI PRESIDENT



Philippine Normal University
The National Center for Teacher Education
College of Graduate Studies and Teacher Education
Research
Pedro Orata Hall, Room 304 B, Taft Avenue, Manila



November 21, 2020

Dr. _____
President
_____ University
Science City of Muñoz, Nueva Ecija

Approved: _____

RECORDS SECTION
RECEIVED
11-21-2020
3886

Dear Dr. _____:

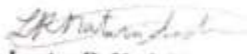
Greetings from the Philippine Normal University!

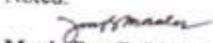
I am a PhD Science Education Student at the Philippine Normal University, Taft Ave., Manila and currently working on my dissertation titled, "*STEAM Education Framework for Senior High School STEM Strand*." The goal of the study is to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Sequentially, the study hopes to produce a training design, a set of indicators and standards as validation products of the framework. The study will employ Strauss and Corbin (1990) grounded theory approach and the SHS science teachers in STEM Strand and their corresponding administrator are the target participants.

In this regard, I respectfully request your good office to allow **Dr. _____** (College of Education Principal) and **Prof. _____** (STEM Teacher) to be interviewed on their experience and perspective in STEM Strand.

Attached herewith are the approval of the PNU ethics committee and DepEd Regional Office on the conduct of my study and the informed consent form where all the details of the study are explained. For queries regarding the study, you may please reach me through natividad.lr@pnu.edu.ph or at my mobile no. 09066760876.

It is with high hope that I would merit your support in this endeavor. Thank you very much and more power.

Very truly yours,

Dexter R. Natividad
 PhD Science Education Student

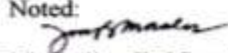
Noted:

Marie Paz E. Morales, PhD
 Adviser



Philippine Normal University
National Center for Teacher Education

APPENDIX K

SAMPLE LETTER REQUEST TO A STEM TEACHER-PARTICIPANT

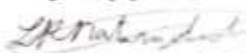
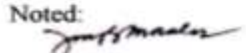
	Philippine Normal University The National Center for Teacher Education College of Graduate Studies and Teacher Education Research Pedro Orata Hall, Room 304 B, Taft Avenue, Manila	
November 23, 2020		
Prof. E. _____ School _____ Science City of Muñoz, Nueva Ecija		
Dear Prof. _____:		
Greetings from the Philippine Normal University!		
I am a PhD Science Education Student at the Philippine Normal University, Taft Ave., Manila and currently working on my dissertation titled, "<i>STEAM Education Framework for Senior High School STEM Strand</i>." The goal of the study is to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Sequentially, the study hopes to produce a training design, a set of indicators and standards as validation products of the framework. The study will employ Strauss and Corbin (1990) grounded theory approach and the SHS science teachers in STEM Strand and their corresponding administrator or principal are the target participants.		
It is in this regard that I kindly request for your participation in the study as the teacher of the chosen school offering STEM strand. Your engagement will focus on an interview regarding your constructs in STEM Strand which will take about an hour or so depending on our discourse.		
Attached are the approval of the PNU ethics committee on the conduct of my study and the informed consent form where all the details of the study are explained. I am hoping for your agreement on my request, and if it merits your approval please indicate agreement by signing the informed consent form. For queries regarding the study, you may please reach me through natividad.lr@pnu.edu.ph or at my mobile no. 09066760876.		
It is with high hope that I would merit your support in this endeavor by your participation in the study. Thank you very much and more power.		
Very truly yours,  Lester R. Natividad PhD Science Education Student		
Noted:  Marie Paz E. Morales, PhD Adviser		



Philippine Normal University
National Center for Teacher Education

APPENDIX L

SAMPLE LETTER-REQUEST TO A STEM ADMINISTRATOR-PARTICIPANT

	Philippine Normal University The National Center for Teacher Education College of Graduate Studies and Teacher Education Research Pedro Orata Hall, Room 304 B, Taft Avenue, Manila	
November 23, 2020		
Dr. _____ Principal, _____ School Science City of Muñoz, Nueva Ecija		
Dear Dr. _____		
Greetings from the Philippine Normal University!		
I am a PhD Science Education Student at the Philippine Normal University, Taft Ave., Manila and currently working on my dissertation titled, "STEAM Education Framework for Senior High School STEM Strand." The goal of the study is to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Sequentially, the study hopes to produce a training design, a set of indicators and standards as validation products of the framework. The study will employ Strauss and Corbin (1990) grounded theory approach and the SHS science teachers in STEM Strand and their corresponding administrator or principal are the target participants.		
It is in this regard that I kindly request for your participation in the study as the principal of the chosen school offering STEM strand. Your engagement will focus on an interview regarding your constructs in STEM Strand which will take about an hour or so depending on our discourse.		
Attached are the approval of the PNU ethics committee on the conduct of my study and the informed consent form where all the details of the study are explained. I am hoping for your agreement on my request, and if it merits your approval please indicate agreement by signing the informed consent form. For queries regarding the study, you may please reach me through natividad.lr@pnu.edu.ph or at my mobile no. 09066760876.		
It is with high hope that I would merit your support in this endeavor by your participation in the study. Thank you very much and more power.		
Very truly yours,  Lester R. Natividad PhD Science Education Student		
Noted:  Marie Paz E. Morales, PhD Adviser		



Philippine Normal University
National Center for Teacher Education

APPENDIX M

INFORMED CONSENT FORM
(adapted from Alma College, Michigan, USA)

Research Title: STEAM Education Framework for Senior High School STEM Strand

Name of Researcher: Lexter R. Natividad

Participant's Name: _____

What is the study about?

This is a research that aims to develop a Science, Technology, Engineering, Arts, and Mathematics (STEAM) Education Framework for Senior High School (SHS) Science, Technology, Engineering and Mathematics (STEM) Strand. A training design and set of indicators and standards will also be developed from the crafted framework.

Why are you asking me?

You are being asked to participate in this study because you are a senior high school teacher teaching in STEM Strand or an administrator of the school with STEM Strand.

What will you ask me to do if I agree to be in the study?

You will be interviewed. A follow up interview may also be done if clarifications are needed. The interview is expected to take about one hour or more depending on your response/s.

Is there any audio/video recording?

The interview/s will be audio or video recorded. Because your voice will be potentially identified by anyone who hears the tape, confidentiality of the things you say on the tape cannot be guaranteed although the researcher will try to limit access to the tape. The video recordings will be strictly confidential.

What are the dangers to me?

Your participation in this study entails minimal risk. Your participation WILL NOT AFFECT your work or your standing in the school. Questions, concerns,



Philippine Normal University National Center for Teacher Education

complaints about this research, benefits or risks associated with being in this study can be addressed to Mr. LEXTER R. NATIVIDAD through his mobile no: 0906-676-0876 or thru email at natividad.lr@pnu.edu.ph.

How will you keep my information confidential?

All information obtained in this study is strictly confidential unless disclosure is required by law. All data will be kept in a locked file cabinet and password protected computer. Your name will be replaced by pseudonym when data are disseminated.

Is there any benefit to society as a result of me taking part in this research?

Your participation in this study may lead to help senior high school science teachers to unravel a new approach that could enhance and enrich their science teaching. Science teachers' instructional practices incorporated in this new approach will not just increase the learners' knowledge, but will also develop students' competencies as future workforce of the country. From this, it is expected that STEAM learning will be more relevant and evocative that the 21st century skills of the learners will be honed strongly and productively to support Industry 4.0. Also, the improvement of instructional process in classrooms through the STEAM approach is expected.

Is there any benefit to me for taking part in this research study?

There is no direct monetary benefit to participants in this study. However, participation in this study may help educators and curriculum developers to create classroom environment with improved STEAM literacy and instruction in senior high school which is aligned with higher education goals in promoting scientific and technological innovations and advancement for the betterment of society and humanity.

Will I get paid for being in the study? Will it cost me anything?

There is no cost or payment for participating in this study.

What if I want to leave the study?

You have the right to refuse to participate or to withdraw at any time, without penalty. If you do withdraw, it will not affect you in any way. If you choose to withdraw, you may request that your data be destroyed or deleted unless a de-identifiable state is in place.



Philippine Normal University National Center for Teacher Education

What about new information/changes in the study?

If significant new information relating to the study becomes available which may relate to your willingness to continue to participate, this information will be provided to you.

Voluntary Consent by Participant: By signing this consent form, you are agreeing that you read, or it has been read to you and you fully understand the contents of this document. By signing this form, you are agreeing that you are 18 years of age or older and are agreeing to participate in this study.

Signature: _____

Date: _____



Philippine Normal University
National Center for Teacher Education

APPENDIX N

**INTERVIEW GUIDE/ AIDE MEMOIRE VALIDATORS AND LANGUAGE
EDITOR'S PROFILE**

Validator 1

Name: **Milano O. Torres**

Affiliation and Rank: **Associate Professor, Graduate School, Bicol State College of Applied Sciences and Technology, Naga City, Camarines Sur**

Highest educational attainment: **PhD Science Education (Philippine Normal University)**

Specialization: **Science Education**

Validator 2

Name: **Elmer D. Dela Rosa**

Affiliation and Rank: **Professor, College of Education, Central Luzon State University, Science City of Muñoz, Nueva Ecija**

Highest educational attainment: **PhD Educational Psychology (De La Salle University)**

Specialization: **Qualitative and Quantitative Research, Educational Psychology**

Validator 3

Name: **Marisol D. Andrada**

Affiliation and Rank: **Master Teacher I, Sto. Nino National High School – SHS, Iriga City, Camarines Sur**

Highest educational attainment: **PhD Science Education (candidate) (Philippine Normal University)**

Specialization: **Science Education, STEM Curriculum, Physics Education**

Validator 4

Name: **Diomedes A. Soriano**

Affiliation and Rank: **Principal, Brilliant Child Academy, Llanera, Nueva Ecija**

Highest educational attainment: **PhD Educational Leadership and Management (Nueva Ecija University of Science and Technology)**

Specialization: **Educational Leadership, Management, Mathematics Education**



Philippine Normal University
National Center for Teacher Education

Language Editor

Name: **Mercedita M. Reyes**

Affiliation and Rank: **Department Head, Department of English and Humanities,
College of Arts and Social Sciences, Central Luzon State
University, Science City of Muñoz, Nueva Ecija**

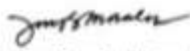
Highest educational attainment: **PhD Literature – English Stream (Philippine Normal
University)**



Philippine Normal University
National Center for Teacher Education

APPENDIX O

SAMPLE LETTER – REQUEST TO INTERVIEW GUIDE/ AIDE MEMOIRE
VALIDATORS

	Philippine Normal University <i>The National Center for Teacher Education</i> College of Graduate Studies and Teacher Education Research Pedro Orata Hall, Room 304 B, Taft Avenue, Manila	
August 20, 2020		
Dr. MILANO O. TORRES Faculty, Graduate School Bicol State College of Applied Sciences and Technology Naga City, Camarines Sur		
Dear Dr. Torres:		
Greetings from the Philippine Normal University!		
I am a PhD Science Education Student at the Philippine Normal University, Taft Ave., Manila and currently working on my dissertation titled, "<i>STEAM Education Framework for Senior High School STEM Strand</i>." The goal of the study is to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Sequentially, the study hopes to produce a training design, a set of indicators and standards as validation products of the framework. The study will employ Strauss and Corbin (1990) grounded theory approach and the SHS science teachers in STEM Strand and their corresponding administrator or principal are the target participants.		
It is in this regard that I kindly request for your expertise and assistance in validating the aide memoire that will be used in the said study. Attached are the objectives of the study, aide memoires, instrument for validator, and the approval of the PNU ethics committee on the conduct of my study for your perusal.		
It is with high hope that I would merit your support in this endeavor through the approval of my request. Thank you very much and more power.		
Very truly yours,		
 Dexter R. Natividad PhD Science Education Student		
Noted:		
 Marie Paz E. Morales, PhD Adviser		



APPENDIX P

VALIDATION INSTRUMENT FOR INTERVIEW GUIDES/ AIDE MEMOIRES

After reading the interview questions and the objectives of the study, please kindly answer the following questions.

1. Are all aide memoires appropriate in grammar, clear and unambiguous? Do they adhere to correct spelling of words, and correct structuring of sentences? If not, kindly elaborate.

2. Does the sequencing of the questions logical? If not, kindly elaborate.

3. Are the questions complete? If not, what do you think should be added in the questions?



Philippine Normal University

National Center for Teacher Education

4. Do you have any suggestions or comments for the improvement of the aide memoirs? Please provide the details.

Thank you for your time 😊



APPENDIX Q

COMMENTS OF VALIDATORS ON THE INTERVIEW GUIDES/AIDE MEMOIRES



Philippine Normal University
The National Center of Teacher Education
Taft Avenue, Manila

Validation Instrument for the Aide Memoire

Name: **MARISOL D. ANDRADA**

Date: **August 23, 2020**

After reading the interview questions and the objectives of the study, please kindly answer the following questions.

1. Are all the aide memoire appropriate in grammar, clear and unambiguous? Do they adhere to correct spelling of words, and correct structuring of sentences? If not, kindly elaborate.

YES

2. Does the sequencing of the interview questions logical? If not, kindly elaborate.

YES

3. Are the interview questions complete? If not, what do you think should be added in the questions?

please see comment on the aide memoire

4. Do you have any suggestions or comments for the improvement of the aide memoire? Please provide the details.

None, the aide memoire is comprehensive enough to gather needed information to answer the research question.

MARISOL D. ANDRADA

Signature of the validator

Thank you for your time ☺



Philippine Normal University
National Center for Teacher Education



Philippine Normal University
The National Center of Teacher Education
Taft Avenue, Manila

Validation Instrument for the Aide Memoire

Name: **MILANO O. TORRES**

Date: **August 21, 2020**

After reading the interview questions and the objectives of the study, please kindly answer the following questions.

1. Are all the aide memoire appropriate in grammar, clear and unambiguous? Do they adhere to correct spelling of words, and correct structuring of sentences? If not, kindly elaborate.

Questions found in the aide memoire, designed for teachers and administrators, adhere with correct rules of grammar and syntax.

2. Does the sequencing of the interview questions logical? If not, kindly elaborate.
Interview questions are logically sequenced, however, I suggest that each concept be crafted with main question. The main question must have probing questions.

3. Are the interview questions complete? If not, what do you think should be added in the questions?

Formulated aide memoire, to my belief, is already complete but consider refinement in some items. Please see suggestions in No. 4.

4. Do you have any suggestions or comments for the improvement of the aide memoire? Please provide the details.

The following are my suggestions for improvement of the interview guide:

- **It is suggested that each concept be crafted with a main question. Existing questions may be retained as probing question or maybe considered/elevated as a main question.**
- **In all instances, please avoid double-barreled questions (please see/review Aide Memoire for Administrators, Instruction and Delivery letter c; Feedback mechanism letter b; STEM Strand letter a).**
- **Please refrain from asking leading question. For example, instead of asking the question, "How about reflective and critical thinking?" re-think of a question where the concept reflective and critical thinking will be drawn from the teachers.**
- **For the Aide Memoire for Administrators, kindly consider: What do you think are the characteristics that your teachers must POSSESS in teaching in STEM Strand?**
- **For the Aide Memoire for Administrators, under Instruction and Deliver (can be phrased as Instructional Delivery), question a can be asked last.**
- **For the Aide Memoire for Teachers, under Institutional Support, phrase the question in a tone as support from the institution not support from principal.**

Signature of the validator

Thank you for your time ☺



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National Center for Teacher Education



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The National Center of Teacher Education
Taft Avenue, Manila

Validation Instrument for the Aide Memoire

Name: ELMER D. DELA ROSA

Date: August 24, 2020

After reading the interview questions and the objectives of the study, please kindly answer the following questions.

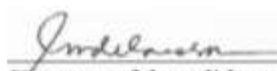
1. Are all the aide memoire appropriate in grammar, clear and unambiguous? Do they adhere to correct spelling of words, and correct structuring of sentences? If not, kindly elaborate.

2. Does the sequencing of the interview questions logical? If not, kindly elaborate.
3. Are the interview questions complete? If not, what do you think should be added in the questions?

1. Does the STEM teacher in the interview protocol for the principal refer to ALL teachers in the school, regardless of subject handled?

2. The central question (a) for curriculum is rather broad. At least features of curriculum and its design must be specified.

3. The framing of the questions seem to tap /anchor on both the principals' and teachers' relative experiences , making it too restrictive. For instance, there is a conceptual and operational difference asking a principal between " What are the characteristics that your teachers must have in teaching in STEM?", and " What are the characteristics that STEM teachers should possess?". Another example is on instruction and delivery. What if teachers respond not having the sufficient preparations in terms of technical, pedagogical and content to teach STEM subject? How will this result help you in the development of a STEAM framework. Looking at specific research question 1, it implies that the needs and constructs shall be derived from the respondents' perspective. Nevertheless, it does not mean limiting it to their actual experiences (making it more inclined to a phenomenological inquiry) notwithstanding the goal of the study to develop a framework to understand STEAM. It is suggested that to make the responses as rich as possible to extract meanings, questions should be asked in generic terms, then the interview can probe into specific experiences.


Signature of the validator

Thank you for your time ☺



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National Center for Teacher Education



Philippine Normal University
The National Center of Teacher Education
Taft Avenue, Manila

Validation Instrument for the Aide Memoire

Name: Diomedes A. Soriano

Date: August 31, 2020

After reading the interview questions and the objectives of the study, please kindly answer the following questions.

1. Are all the aide memoire appropriate in grammar, clear and unambiguous? Do they adhere to correct spelling of words, and correct structuring of sentences? If not, kindly elaborate.

Yes, all aide memoires adhere to correct grammar. They are also clear and unambiguous.

2. Does the sequencing of the interview questions logical? If not, kindly elaborate.

YES

3. Are the interview questions complete? If not, what do you think should be added in the questions?

Yes, for me it is complete and comprehensive enough.

4. Do you have any suggestions or comments for the improvement of the aide memoire? Please provide the details.

Please add more follow up questions on the curriculum and institutional support. You may also add more questions regarding the STEM Education practiced in their school.

(SGD) Diomedes A. Soriano

Signature of the validator

Thank you for your time ☺



AIDE MEMOIRE FOR STEM TEACHERS

Good day! I am Lexter R. Natividad. You can call me Lex. I am a PhD Science Education Student at the Philippine Normal University. Presently, I am working on my dissertation titled, ***“STEAM Education Framework for Senior High School STEM Strand.”*** This is a study anchored on the grounded theory approach that aims to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Also, the study hopes to produce training design, indicators and standards as validation products of the framework.

As a vital part of this academic endeavor, I am inviting you to a one-to-one interview session that will determine your needs and capture your constructs on STEM Strand which may inform the STEAM Education Framework. This activity will be recorded and you may answer in either English or Filipino whatever is convenient for you.

Before we start, I would like to ask again for your consent to take part in this study. This activity will take one hour or more depending on your response. Do you have any question or concern before we proceed? Okay, let's start.

Data Aspect	Accounts
Respondents' Robotfoto	Your name: _____ Age: _____ The pseudonym you want to use in the study: _____ Your civil status: ___ Single ___ Married ___ Widow Your place of residence: _____ Your education: College: ___ Graduate ___ PhD (Course: _____) ___ Masters (Course: _____) ___ Undergraduate (Course: _____) Specialization: _____ Length of Teaching Experience (over-all): _____ yrs Length of Teaching Experience in STEM Strand: _____ yrs Subjects taught in STEM Strand:



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Concept	Interview Questions
<i>Pedagogical Traits and Characters</i>	What do you think are your characteristics that qualify you to teach in the STEM Strand? b. How do you maintain your reputation as a good STEM teacher?
<i>Curriculum</i>	What do you think of the STEM curriculum and design? c. Do you think the curriculum is comprehensive enough for the students? d. Do students get the skills needed in the curriculum at present? e. Does the present curriculum meet the objectives of the DepEd to produce students who will take courses in STEM fields? f. Why do you think so?
<i>Instruction and Delivery</i>	On a scale of 1 to 10, how do you rate your overall knowledge in the STEM Subjects? b. Why do you say so? Do you think you have sufficient preparation (in terms of technical, pedagogical, and content) to teach STEM subjects? b. Why or why not? What other fields do you think are necessary in learning and teaching STEM? b. How do you rate your content knowledge in each of these fields? How do you promote innovative, active, engaging, and collaborative learning in the class? c. How about reflective and critical thinking? d. How do you structure your teaching activities in STEM? Do you find the STEM subjects difficult or problematic in any way? b. Why do you think so?
<i>Feedback System</i>	How do you assess your students? b. What are your criteria in the selection of assessment tools? How did you establish students' consultation in class?
<i>Learning</i>	Learning environment is an important aspect in teaching.



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<i>Environment</i>	c. How do you promote and maintain safe learning environment in school? d. How do you effectively manage your students during class?
<i>Institutional Support</i>	What support mechanisms have you received from your institution for your teaching? If you were an administrator, what support would you give to your teachers?
<i>STEM Strand</i>	What can you say about the SHS STEM Strand in general? c. How would you describe your overall teaching experience in STEM Strand? d. If you could improve or change any aspect of STEM Strand, what would it be and why?
<i>CLOSING</i>	
Finally, before we end this activity, is there anything else you feel I should know about STEM Strand? <i>(Give key points of his/her answers, this may also confirm his/her answers)</i> I already have the accounts needed for my study. I hope you are still available if I need more elaboration of your answers in case, I missed something. Thank you very much for your time and active participation.	



APPENDIX S

AIDE MEMOIRE FOR STEM STRAND ADMINISTRATORS

PREAMBLE

Good day! I am Lexter R. Natividad. You can call me Lex. I am a PhD Science Education Student at the Philippine Normal University. Presently, I am working on my dissertation titled, ***“STEAM Education Framework for Senior High School STEM Strand.”*** This is a study anchored on the grounded theory approach that aims to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Also, the study hopes to produce training design, indicators and standards as validation products of the framework.

As a vital part of this academic endeavor, I am inviting you to a one-to-one interview session that will determine your needs and capture your constructs on STEM Strand which may inform the STEAM Education Framework. This activity will be recorded and you may answer in either English or Filipino whatever is convenient for you.

Before we start, I would like to ask again for your consent to take part in this study. This activity will take one hour or more depending on your response. Do you have any question or concern before we proceed? Okay, let's start.

Data Aspect	Accounts
Respondents' Robotfoto	Your name: _____ Age: _____ The pseudonym you want to use in the study: _____ Your civil status: ☐ Single ☐ Married ☐ Widow Your place of residence: _____ Your education: College: ☐ Graduate ☐ PhD (Course: _____) ☐ Masters (Course: _____) ☐ Undergraduate (Course: _____) Length of Teaching Experience (over-all): _____ yrs Length of Teaching Experience in STEM Strand: _____ yrs Length of Administrative experience (over-all): _____ yrs Length of Head or administrator in STEM Strand: _____ yrs Subjects taught in STEM Strand previously: _____



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Concept	Interview Questions
<i>Pedagogical Traits and Characters</i>	What are the characteristics that your teachers must possess in order to teach in STEM Strand? - Why do you say so? - What are your indicators that a teacher is a good STEM teacher?
<i>Curriculum</i>	What do you think of the STEM curriculum and design? - Do you think the curriculum is comprehensive enough for the teachers and students? - Why do you think so?
<i>Instruction and Delivery</i>	Do you think your teachers have sufficient preparation (in terms of technical, pedagogical, and content) to teach STEM subjects? - Why or why not? What other fields do you think are necessary in learning and teaching STEM? - How do you rate your teachers' content knowledge in each of these fields? How do you help your teachers in promoting active, engaging, and collaborative learning in the class? - How about in reflective and critical thinking? Do you think your teachers find the STEM subjects difficult or problematic in any way? - Why do you think so? On a scale of 1 to 10, how do you rate your teachers' overall knowledge in the STEM Subjects? - Why do you say so?
<i>Feedback System</i>	How do you manage/handle your teachers? - What arrangement or structure do you adopt in using the assessment and feedback system for the improvement of the curriculum and practice? - What do you think are the weaknesses and strengths of this system?
<i>Learning</i>	Learning environment is an important aspect in teaching.



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<i>Environment</i>	a. How do you ensure and promote safe learning environment in your school? b. How do you monitor your teachers' classroom management?
<i>Institutional Support</i>	What are the support mechanisms that you give to your teachers? d. How do you encourage your teachers to attend trainings related to but not limited to contextualization, collaborative learning, and assessment? e. Do you think the teachers received support well from the school? f. Why do you say so?
<i>STEM Strand</i>	What can you say about the SHS STEM Strand in general? a. How will you describe your overall administrative experience in STEM Strand? b. If you could improve or change any aspect of STEM Strand, what would it be and why?
<i>CLOSING</i>	
Finally, before we end this activity, is there anything else you feel I should know about STEM Strand? <i>(Give key points of his/her answers, this may also confirm his/her answers)</i> I already have the accounts needed for my study. I hope you are still available if I need more elaboration of your answer in case, I missed something. Thank you very much for your time and active participation.	



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APPENDIX T

**INFORMED CONSENT FORM FOR AUDIO- OR VIDEO- RECORDING AND
TRANSCRIPTION**

(adapted from Kean University, New Jersey)

**Research Title: STEAM Education Framework for Senior High School STEM
Strand**

Name of Researcher: Lexter R. Natividad

Participant's Name: _____

This is a research that aims to develop a Science, Technology, Engineering, Arts, and Mathematics (STEAM) Education Framework for Senior High School (SHS) Science, Technology, Engineering and Mathematics (STEM) Strand. A training design and set of indicators and standards will also be developed from the crafted framework.

This study involves the audio or video recording of your interview with the researcher. Neither your name nor any other identifying information will be associated with the video or audio recording or the transcript. Only the research team will be able to listen (view) to the recordings.

The recording will be transcribed by the researcher and erased once the transcriptions are checked for accuracy. Transcripts of your interview may be reproduced in whole or in part for use in presentations or written products that result from this study. Neither your name nor any other identifying information (such as your voice or picture) will be used in presentations or in written products resulting from the study. Only pseudonym of your choice will be used.

By signing this consent form, you are agreeing that you read, or it has been read to you and you fully understand the contents of this document. By signing this form, you are agreeing that you are 18 years of age or older and are agreeing to participate in this study. Also, you understand that this consent for recording is effective until August 2022. On or before that date, the recordings will be deleted or destroyed.

Signature: _____

Date: _____



APPENDIX U

SAMPLE FIELD NOTES

December 11, 2020
Google Meet
7:38 pm - start

Pseudonym - Michael
"Strigle"
Address: Zamboanga, Marikina City
Undergrad: BS Ed major in Physical Sciences
CLSU
Master: MEd major in Integrated Science
PNV

3 years teaching experience
3 years in STEM

Subjects

- General Physics 1 & 2
- General Chemistry 1
- Media and Information Literacy →
↳ had extracurricular activities in publications
- Journalist

* Characteristics of a STEM Teacher

- degree in education
- interest in Science
- willingness to change → Worth
change

* reputation

- quality instruction → activity-based
- knowledgeable on the trends

So he started teaching in STEM Strand?

How? Science major but teaching Media and Information Literacy?



* What can you say about STEM curriculum and design

- too much content
- congested
- overlapping of subjects
- repetition
- JHS have SITS complex

There is overlapping and repetition

- Competency-based curriculum
- ~~OP~~

Other lessons were combined just to finish all the course...

"Some STEM students are only there because their social group"

STEM → social sciences courses
→ Criminology

- content knowledge - 9
- Pedagogy - 9

* How do you promote innovation

- students are free
- parabolic motions - let them do their own parabola

* Structure of teaching activities

- motivation
- creativity
- orderliness

STEM subjects are difficult



- complexities of the subjects

* ASSESSMENT

- reliability
- relevance
- more on affective, psychomotor
- There is problem in laboratories
 - ~~long~~ materials
 - lacking facilities
 - X ventilation
 - no first aid kits

Maturity

- students ✓

* SUPPORT

- training
- seminars
- moral support

CATALYST for innovation, they can think of something new

- Some are favored
- there is favoritism who will attend
- There are many places to go, fun seminars
LAC, in-service training, ~~con~~, ~~con~~



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What can you say about STEM school?

- 3I's like OJT, make it longer
- focus more on the subject matter
- ~~the~~ like MELC's
- decongest the curriculum
- strengthen the partnership with the science institutions

"One competency, one topic, one week, it is doable!"

How long is the immersion of students in their OJT?

Is there a MOA?

Science institutions such as ~~AD~~ DOST, NIA, PhilRice, PhilMECH, BFAR

TEACHING EXPERIENCE IN STEM SCHOOL?

- happy - enjoyable
- In STEM school, skills are attained

— END OF INTERVIEW —
8:36 pm



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APPENDIX V

CONTACT SUMMARY SHEET

Name: _____ Date of interview: _____
Pseudonym: _____ Time: _____
Position: _Teacher Date of accomplishing this form: _____
 _ Administrator
Type of SHS: Modality of Contact: ___ google meet
 ___ Public Integrated JHS – SHS ___ zoom
 ___ Public Stand alone SHS ___ face to face
 ___ Private SHS ___ others pls specify:
 ___ HEI with SHS
 ___ Private HEI with SHS

1. Main issues/themes/concepts given by the contact helpful in the study

2. Summary of information obtained (or not) on each of the questions

3. Any other salient, illuminating, interesting, or important points



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4. New or remaining target questions for next contact

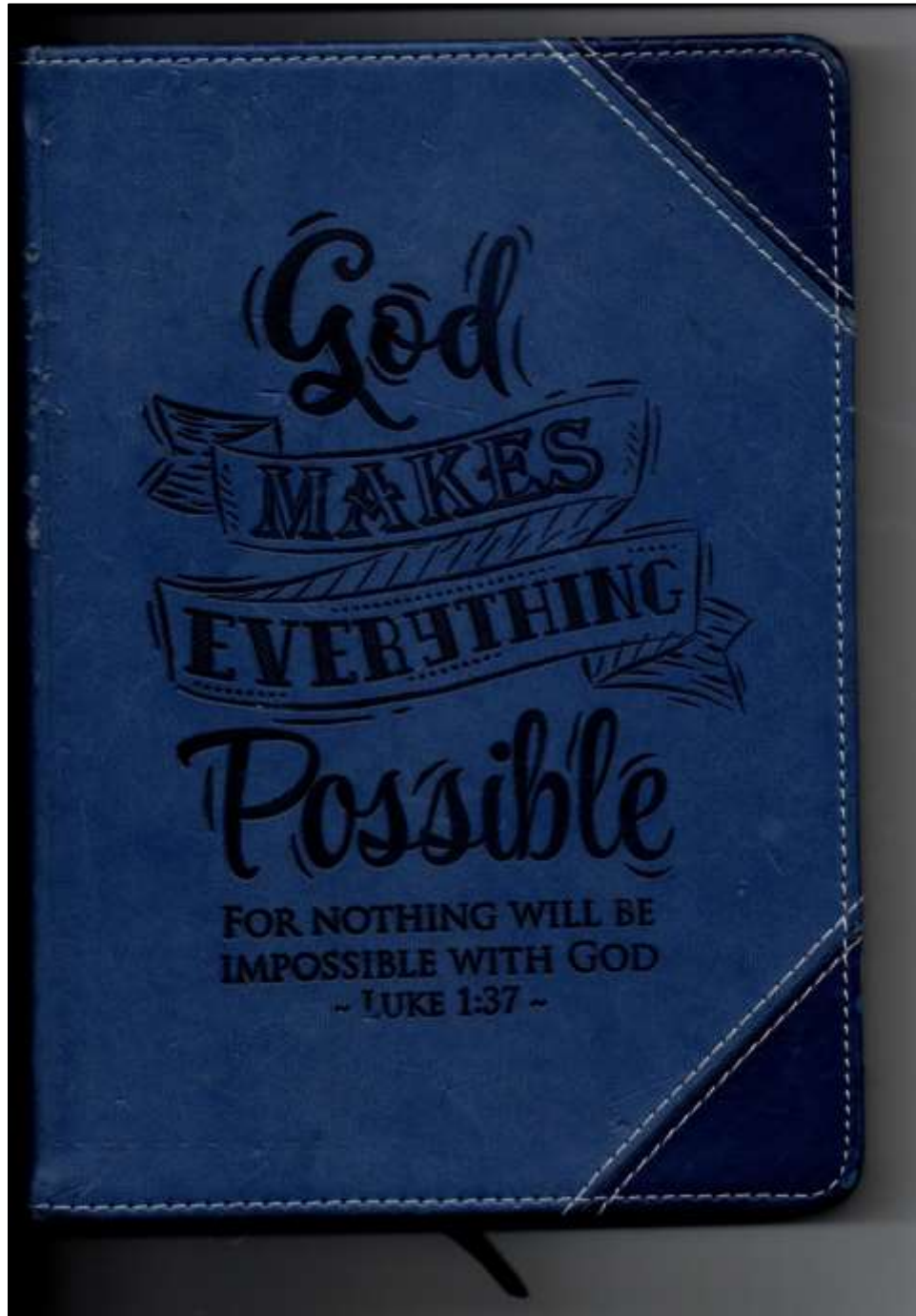
5. Other Concern/s:



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APPENDIX W

THE DEDICATED NOTEBOOK FOR MEMOING OF THE RESEARCHER





APPENDIX X

SAMPLE MEMOS ACCORDING TO CATEGORY

Observation Notes

November 26, 2020

I felt that my interviewee today is hesitant to say that his school where he was employed ~~that~~ is unsupportive to him in terms of his professional growth for STEM strand. I asked him if he has attended trainings or seminars in lieu of his employment. He answered "none." On the last latter part of the interview, he said that there is one from his co-teachers who is always being sent to participate in the seminars. The interviewee stated, "We all think that she is the favorite of our principal."

For You, O LORD.

Methodological Notes

December 29, 2020

I notice that most of the respondents preferred the 7-10 pm time slot to be interviewed. When I asked them for their reason, several of them answered that such time slot is the ideal time because their household duties and online classes are already done.



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Theoretical Notes

January 19, 2021

I have written several open codes for the question about curriculum, such as, Congested, repeated topics, and misalignment. Does the "Curriculum refinement" a suitable category for the open codes?

Personal Notes

surround him as with a shield.
Psalm 34:7

January 7, 2021

Transcribing and translating interview are so difficult. Then coding will add up another burden. Truly, qualitative research is a very tedious process. Will I be able to finish my dissertation in time?



APPENDIX Y

SAMPLE TRANSCRIBED AND TRANSLATED INTERVIEW

Interviewer	Interviewee	Translation
Good day! I am Lexter R. Natividad. You can call me Lex. I am a PhD Science Education Student at the Philippine Normal University. Presently, I am working on my dissertation titled, <i>“STEAM Education Framework for Senior High School STEM Strand.”</i> This is a study anchored on the grounded theory approach that aims to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Also, the study hopes to produce training design, indicators and standards as validation products of the framework. As a vital part of this academic endeavor, I am inviting you to a one-to-one interview session that will determine your needs and capture your constructs on STEM Strand which may inform the STEAM Education Framework. This activity will be recorded and you may answer in either English or Filipino whatever is convenient for you. Before we start, I would like to ask again for your		



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consent to take part in this study. This activity will take one hour or more depending on your response. Do you have any question or concern before we proceed?		
Okay, let's start.	So far, I have no question.	
Sir your complete name please	XXXXXXXXXXXXXXXXXX	
Age Sir?	26 years old	
Sir in this study what pseudonym do you want to use?	Michael	
Civil Status?	Single	
Address?	XXXXXXXXXXXXXXXXXXXXXXXXXXXX	
What is your undergraduate course Sir?	I took Bachelor of Secondary Education major in Physical Sciences	
In what school?		



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And your master? what school? Overall Sir, what is your length of experience? So over all Sir that is the length of your teaching experience is three years, am I correct? So does it mean sir that you started your teaching experience in senior high school?	Central Luzon State University I am taking up Master of Science Education major in Integrated Science PNU Including my recent experience, three years na po. Yes Sir. Yes, Sir.	<i>Including my recent experience, three years already.</i>
What are the subjects you already taught? Specific sir, what are the subjects?	Core subjects and specialized subjects. I taught media and information literacy,	



Okay. Hmmm media literacy?	I also taught General Physics 1 and 2, General Chemistry 1	
Okay	Also, ah, nakalimutan ko na yata Sir yung iba pero meron pa yan	<i>Also, ah, I already forgot Sir but there are still others</i>
Sir you really teach media and information literacy?	Yes Sir	
I will start there, Sir. Is media literacy related to your course? Didn't you have a hard time teaching the subject?	Hindi naman po Sir. Even though hindi nakaalign sa majorship natin pero may dahil extra curricular naman ako sa college nun, on publication, nakuha naman natin Sir.	<i>Not really Sir. Even though it was not aligned with our majorship but because I had extracurricular on college, on publication, I got it Sir.</i>
Ah okay. So you didn't have much trouble?	Hindi naman po Sir	<i>Not really Sir.</i>
So, I mean you were a journalist then, am I right?	Yes Sir, Opo	<i>Yes Sir. Yes</i>



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In physics, it is okay since it is aligned in your course. Am I right?	Opo	Yes
Ahm, for you Sir, what do you think are the characteristics you possess why you are teaching in STEM Strand?	I think Sir the degree that I finished in Education. Also, kung isasama natin yung opinion, yung opinionated answers din, I really do love Science. It really helps the interest to teach science as well as to learn in the field. Kasi ganun naman lagi eh Sir di ba?	<i>I think Sir the degree that I finished in Education. Also, if we include the opinion, the opinionated answers as well, I really do love Science. It really helps the interest to teach science as well as to learn in the field. It's always like that, isn't it, sir?</i>
In other words, you have the passion right?	Yes Sir	
So aside from the degree, passion. But if you are the one to make the choice, pretend you are the boss, do you have anything else to look for when you hire?	Siguro isama natin ang willingness to change kasi maaaring in the near future, magbago yung science curriculum	<i>Maybe we can include the willingness to change because maybe in the near future, the science curriculum will change</i>
Ah so okay	Willingness to change kasama din po	<i>Included also is the willingness to change</i>



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Sir, how do you maintain your reputation as a good STEM Teacher? Okay I am interested sir in what you said "good and quality instruction." How do you, sir, define good and quality instruction?	Ayan, ano, siguro, good and quality instruction, unang una yun Kasi dapat magagaling magturo, dapat sumabay tayo sa kanila. Siguro iapply di natin yung diversity approach kasi kung stay tayo sa tough job as STEM Teacher, alam dapat natin. Dapat yung mga activity-based instruction alam din natin. And being knowledgeable to the current information din po, kasi baka may nagbago na sa sciences eh. Andaming pwedeng magbago on the content of what you are teaching. Ahm para sa akin may good and quality instruction kapag may good communication with the students or learners. Kapag hindi sila na bore sa klase mo. Yung kahit na araw araw ka nilang nakikita, the students are still inspired to learn from you	<i>There, maybe, good and quality instruction, first of all</i> <i>Because we must be good at teaching, we must go with them. Maybe we will also apply the diversity approach because if we stay in a tough job as a STEM Teacher, we should know. We should also know the activity-based instructions. And being knowledgeable to the current information as well, because maybe something has changed in the sciences. Many can change on the content of what you are teaching.</i> <i>Ahm for me there is good and quality instruction when there is good communication with the students or learners. When they are no longer bored with your class. Even though they see you every day, the students are still inspired to learn from you</i>



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Okay Sir. What do you think of the STEM curriculum and design?	Sa ngayon Sir, ang Senior High, sa tingin ko Sir sobra pa ring daming laman.. sobra pa ring daming content... Congested. Madami gustong ipaturo. Kahit sabihin natin Sir na nakaspiral tayo, parang andami pa ring pwedeng ialis na topics. Tapos kung minsan, nagooverlap pa yung mga topics. Yung mga topics ng Grade 9 at Grade 10, nauulit. Kung pwede sanang idecongest.	<i>Right now Sir, Senior High, I think Sir it is still too much content .. still too much content... Congested. Many want to be taught. Even if we say Sir that we are in spiral, it seems like there are still many topics that can be removed. Then sometimes, the topics even overlap. The topics of Grade 9 and Grade 10, are repeated. If possible, decongest.</i>
So Sir for you the spiral progression from JHS to SHS is not effective?	Yes sir nagagamit naman. Pero parang may konti lang na repetition. Parang halimbawa basic tinuro sa JHS, complex naman sa SHS	<i>Yes sir it can be used. But there seems to be little repetition. For example basic was taught in JHS, complex in SHS</i>
Ah okay. So it seems like strategy too. What else Sir?	Meron pa po sigurong room for improvement talaga sa subjects. Pwede pang magbago, pwede pang mag improve.	<i>Maybe there is still room for improvement in subjects. Can still change, can still improve.</i>
Sir, do you think the curriculum is comprehensive enough for		



the students?		
	Dahil competency-based naman yung curriculum natin, sa tingin ko namimeet naman po. Nasa strategy din, minsan pinagsasama yung mga topics para maturo ng mabilis. I integrate the two topics. Pero time wise napakahirap.	<i>Because our curriculum is competency-based, I think it is being meet. Also in strategy, sometimes combining topics to finish teaching quickly. I integrate the two topics. But time wise it is very difficult.</i>
So it looks like you just did everything just to meet the minimum requirement.		
	Opo. Up to the point magtanggap tayo ng iba at nang maipakita natin ang important lessons	<i>Yes. Up to the point that we delete others so that we can show the important lessons.</i>
So you're just choosing what, the topics you are going to teach?		
	Yes sir. Parang makikita mo naman na yung competency na yun ay pwede mo nang isama sa other competency kaya matatanggal na siya mismo dun sa list ng competencies, parang mawawala na siya dun.	<i>Yes sir. It looks like you can see that competency, you can include it in other competencies so that it can be removed from the list of competencies, it looks like it will be removed there.</i>
Sir, are the topics that DepEd put in the STEM Curriculum, is it teachable to students?		
	Teachable naman Sir. Para sa akin lang, hard for them to learn.	<i>It is teachable Sir. Just for me, hard for them to learn.</i>



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Why, Sir?	Kasi Sir, we accept students from STEM strand kasi alam natin na kukuha sila ng STEM related fields pero sa scenario natin ngayon, some STEM students are only there kasi nandun yung barkada but the degree that they will take in College is non STEM so parang nahihirapan talaga sila kasi di naman din yung field of interest nila. Wala yung interest nila, hindi na nila nagagamit sa college ganun ba. That is for my experience, Sir. Yung mga nasa STEM magtutuloy lang pala ng social science, magtutuloy lang pala ng criminology.	<i>Because Sir, we accept students from STEM strand because we know that they will take STEM related fields but in our scenario now, some STEM students are only there because their social group is there but the degree that they will take in College is non STEM so it seems difficult for them since that is really not their field of interest either. They have no interest; they can no longer use it in college like that. That is for my experience, Sir. Those in STEM will just continue with social science, will continue with criminology.</i>
Which is not for STEM but for HUMMS	Yes Sir, saka yung factor na puno na kasi sa HUMMS kaya sila papasok sa STEM.	<i>Yes Sir, and the factor that the HUMMS is already full that is why they will take STEM</i>
But Sir, you feel, there is a student factor?	Several factors po Sir eh. Pero di rin naman siya sa curriculum. Kasi kung interest nawala, andun pa din naman yung ibang bagay sa subject matter.	<i>Several factors Sir. But not in the curriculum. Because if interest is lost, there are still other things in the subject matter.</i>



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On a scale of 1 to 10, how do you rate your overall knowledge in the STEM Subjects?	Ahm. I think 9.	
So for you Sir, content wise you are very knowledgeable in the field.	Yes sir, I think I am knowledgeable and qualified.	
How about Sir in terms of preparations, do you think you are sufficiently prepared in technology?	Looking at the standards today in our classroom settings, I think I am competent enough. Pero kapag kinompare natin internationally, makikita natin sa teaching tools at strategy nila na lower enough po tayo pati sa competencies	<i>Looking at the standards today in our classroom settings, I think I am competent enough. But when we compare internationally, we can see in their teaching tools and strategy that we are lower enough as well as in competencies</i>
How about Sir in terms of your pedagogy? Are you prepared?	Pedagogy-wise Sir, I can say I am still novice in the field. Kahit ako sa sarili ko Sir andami ko pang mali na ginagawa. Sobra pa pong kulang sa experience. Hilaw pa sir, hilaw na hilaw.	<i>Pedagogy-wise Sir, I can say I am still novice in the field. Even I, myself, Sir I still do a lot wrong. I am too much lacking in experience. Raw sir, too</i>



But as you said, you are willing to change right? But you also said sir content-wise, you are okay with the subjects?	Yes sir and everytime po na may evaluation sa school, napakasarap pong tanggapin ang mga feedbacks. Marami ka pong napupulot as well as with the seminars. Yes Sir.	raw. <i>Yes sir and everytime there is an evaluation at the school, it is very nice to receive feedbacks. You pick up a lot as well as with the seminars.</i>
Sir if you were to include a field in the STEM Strand, what subject would you like to include? So do you think our subjects are okay Sir?	Wala naman Sir out of the moment. Okay naman Sir yung mga subjects natin pero for improvement, I think meron pa rin.	<i>None Sir out of the moment</i> <i>Our subjects are okay Sir, but for improvement, I think there are still some.</i>
In your class Sir, how do you promote innovations in the class?	I let my students. Hinahayaan ko lang sila na magsuggest different things, kasi mature naman na din yung mga bata na yan eh. So	<i>I let my students. I just let them suggest different things, because those kids are also mature. So every time they do experiments or</i>



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Yes And is that effective sir? Is there creativity coming out?	everytime na gumagawa ng experiments o classroom activities kahit nakaupo lang sila, binibigay ko yung outcome ng activity and sila yung bahalang pwedeng mag suggest kung ano ang gusto nilang gawin doon. For example Sir, sa Physics activities namin na parabolic motions. Imbes na magprovide ako ng improvised device, hinahayaan ko sila na magsuggest kung ano gusto nila gamitin to make a parabola. Kasi makkikita mo rin naman sir na marami o malawak ang pwedeng nilang ibigay, so dun Sir I think innovative sila. Yes sir. Kasi ang daming competency na nachecheck kaagad doon eh. Sobrang hands -on dun talaga sa may activity na yun.	<i>do classroom activities even if they are just sitting, I give the outcome of the activity and they are the ones who suggest what they want to do there. For example, Sir, in our Physics activities such as parabolic motions. Instead of providing an improvised device, I let them suggest what they want to use to make a parabola.</i> <i>Because you can also see sir that they can give many or a lot, so then Sir I think they are innovative.</i> <i>Yes sir. Because a lot of competencies was checked right there. It's really very hands-on with that activity.</i>
Do you promote collaboration among your students during class?	Kahit sa mga activities sir, ianaallow po natin ang	<i>Even in our activities Sir, we allow collaboration</i>



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Sir when you teach on the STEM strand, how do you structure or plan your teaching activities?	collaboration Parang lesson plan lang din po Sir. From motivation to evaluation kasi yun na din nakasanayan natin eh, pero there are times din na we need to adjust na gawin yung ganung scenario. Kasi may times na nagiging effective si activity muna, then you discuss things and motivational experience on how you can apply the lesson in their life.. parang ganun po sir.. Nakikita kong parang gusto nila ng bago. Ayaw rin minsan nila ng paulit ulit. Ganun na rin kasi nakasanayan ng iba kaya lang iba na rin kasing magisip student natin.. parang ganun.	<i>It looks like a lesson plan, sir. From motivation to evaluation because that's what we're used to, but there are also times when we need to adjust to do such a scenario. Because there are times when the activity becomes effective first, then you discuss things and motivational experience on how you can apply the lesson in their life .. it seems like that sir .. I see it as if they want something new. They also sometimes do not want to repeat. It's the same because others are used to it, it's just that our students think differently .. it seems like that.</i>
When you teach sir, do you have any skills you want to impart to them?	Apart from problem solving skills talaga Sir, I want them to enhance their creativity in solving problems, as their orderliness in solving problems. Kasi Sir nawawala na po yun ngayon eh.	<i>Apart from problem solving skills Sir, I want them to enhance their creativity in solving problems, as their orderliness in solving problems. Because Sir, it's disappearing now. There</i>



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	Andami ding nagiging issue about handouts kaya di na sila nagtetaake down notes sa discussion. Para sa akin mas gusto ko pa rin yung nagtatake down notes sila. Ibalik sa kanila yung ganun.	<i>are also many issues about handouts so they no longer take down notes in the discussion. For me, I still prefer taking down notes. Give them that back.</i>
Do you find the STEM subjects difficult or problematic in any way?	Personally Sir, I think they are difficult. They are difficult in terms of the learning abilities of the students. Siguro dahil na rin sa dami ng subjects o lessons na dapat nila makuha. Kahit sila Sir nahihirapan na magprocess ng information kasi sa dami.	<i>Personally Sir, I think they are difficult. They are difficult in terms of the learning abilities of the students. Maybe because of the number of subjects or lessons they should get. Even they Sir find it difficult to process information because of the quantity.</i>
Especially science right?	Nagbato ka nung lunes, kailanagan nung martes integrated na nila yun. Tapos miyerkules ganun na naman, huwebes ganun pa rin.. bato tayo ng bato ng content sa kanila Sir and para sa kanila nahihirapan an rin siguro sila kasi hindi lang po tayo ang subjects	<i>You threw on Monday, they need to be integrated on Tuesday. Then Wednesday is like that again, Thursday is still the same .. we are throwing them content Sir and for them they are also maybe having a hard time because we are not the only subjects</i>
Yes	Tapos yung complexities na rin ng subjects po Sir	<i>And also because of the complexities of the subjects Sir</i>



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Others say so. When the subjects are the same and then math and science seem to be together	Though hindi po natin Sir maaalis na meron pong mga students na mareklamo. “Sabay sabay naman, ganun po sila” Nakikita din naman po kasi natin talaga na mahirap para sa kanila	<i>Though we can't get rid of it Sir that there are students who complain. "They were altogether, they are like that" We also see that it is really difficult for them</i>
In terms Sir of assessment, how do you assess your students? Okay relevance	Siyempre Sir andun pa rin po yung reliability ng assessment tools, at saka relevance niya sa topic And also the relevance in the competency na kailangang imeasure. Dahil sobra tyong competency based sa curriculum, hindi pwede tayong lumayo doon. Kahit gusto pa nating kukuha ng affective, psychomotor, magiging focus tayo kay competency which is para sobra tayong restricted na gumawa ng mga ganoong exams in assessment	<i>Of course Sir, there is still the reliability of the assessment tools, and also its relevance to the topic</i> <i>And also the relevance in the competency that needs to be measured. Because you have too much competency based on the curriculum, we cannot stay away from it. Even if we still want to get affective, psychomotor, we will focus on competency which is restricted for us to do such exams in assessment</i>
Do you allow consultation in your class?	Yes sir the consultations are allowed in our class. During	<i>Yes sir the consultations are allowed in our class.</i>



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What do students usually consult with you?	activity open po tayo doon and after class Usual lang din Sir. May example na hindi nakuha, pano daw yun nangyari. Pano nakakarating sa ganung end product. Meron din pong out of the box consultation, mga pangyayari sa buhay, mga out of the lesson na consultation	<i>During activity, we are open for that, and after class</i> <i>It is usual Sir. There is an example that they did not get, how did that happen. How do you get to such an end product? There are also out of the box consultations, life events, out of the lesson consultations</i>
How about Sir, in our curriculum, in laboratory activities, is it enough? Maybe because the topic is also congested then you need to perform laboratory activities	Sa curriculum natin Sir sa laboratory activities parang konti talaga Sir. Parang mas okay na 50/50 discussion laboratory tayo. Kaya lang hindi nagagawa Yes sir kasama na rin diyan. Kasi sir yung materials at facilities, diyan din kasi yung kulang eh.	<i>In our curriculum Sir, in laboratory activities, seems really little Sir. It seems more okay for a 50/50 discussion laboratory. But then, it is not being done.</i> <i>Yes sir that includes that too. Because sir the materials and facilities, there are also those that are lacking.</i>
Sir do you think in the school, they have safe environment?		



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How about sir your classroom management?	Yes sir opo. Kaya lang facilities natin sa laboratory, wala tayong ventilation eh. Kulang tayo sa mga materials at mga first aid kit. Cguro sir 80% safe.	<i>Yes sir yes. However, in our laboratory facilities, we don't have ventilation. We lack materials and first aid kits. Maybe sir 80% safe.</i>
In terms of maturity, is SHS students okay sir?	Same din sa may pedagogy. Dahil wala pa po akong ganung experience, bago bago pa lang. Three years is nowhere enough for a real classroom setting para po sa akin Sir. Sa noise reduction kinakaya naman. Yung mga STEM Student are known for their behavior na tutok naman sa topic, pag naglaro sila mahihirapan na sila.	<i>Same with pedagogy. Because I have never had such an experience, just recently. Three years is nowhere enough for a real classroom setting for me Sir. Noise reduction is possible. STEM Students are known for their behavior that is focused on the topic, when they play, they will have a hard time.</i>
What are the support mechanisms you received from your institution in your teaching?		



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Have you ever asked Sir which has not been granted or none yet?	In the year of my experiences, I received support on training, seminars and instructions. Wala namang financial assistance pero meron namang moral support. Yung administration naman palagi silang andyan.	<i>In the year of my experiences, I received support on training, seminars and instructions. There is no financial assistance but there is moral support. The administration is always there .</i>
How do you feel Sir in that case?	Marami na Sir. Maraming times na lalo na pag nanghihingi ng materials. You cannot blame the administration dahil limited din yung funds.	<i>Many Sir. Many times especially when asking for materials. You cannot blame the administration because the funds are also limited.</i>
Hypothetically Sir, when you become the administrator of a school, what support will you give to your teachers?	Wala yata dapat po akong maramdaman Sir kasi sila ang administrator. It is my decision to suggest but still prerogative nila yun. Pero ang iniisip ko na lang eh na hindi dapt yun maging hindrance sa mga bata in learning. Iniisip ko na maging catalyst na lang ito sa innovation at dahil wala ngang gamit, nakakapag isip sila ng bago.	<i>I don't think I should feel anything Sir because they are the administrator. It is my decision to suggest but it is still their prerogative. But I just think that it should not be a hindrance to children in learning. I think it will just be a catalyst for innovation and since there is no material, they can think of something new.</i>



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Are the trainings and seminars Sir you got enough?	I will support my teachers kung anong meron ako. If I don't have enough budget for our school, I will give them the experience that I have been, the lessons that I have. In strategies they lack. Kasi may experience na ako that I saw that in my administrator Kung pagbabatayan natin Sir ang kalakaran, they are nowhere near enough. Kasi aminin natin Sir na some are favored while if you want to attend naman, expensive hindi binibigay sa atin ng libre yung mga yan. That's one of the major reasons kung bakit hindi nagiging enough yung mga trainings at seminars. Andami pa sanang pwedeng puntahan, masayang puntahan na seminar na makakatulong, pero wala talagang money eh.	<i>I will support my teachers with what I have. If I don't have enough budget for our school, I will give them the experience that I have been, the lessons that I have. In strategies they lack. Because I have experience that I saw in my administrator</i> <i>If we base Sir on the trend, they are nowhere near enough. Because let's admit Sir that some are favored while if you want to attend, expensive, those are not given to us for free. That's one of the major reasons why trainings and seminars don't become enough. There are many more places to go, fun seminars to help, but there is really no money.</i>
What can you say about the SHS STEM Strand in general?	I will point in one single subject, on their integration. They have 3I's tama Sir? On their 3Is, I would like to make it longer in period kasi sir yun ang parang OJT nila tama po?	<i>I will point in one single subject, on their integration. They have 3I's, correct Sir? On their 3Is, I would like to make it longer in period because sir it seems like their OJT</i>



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Yes	Then most of the school cannot afford to send their students in their respective field of interest, kung minsan ang nangyayari na lang sir ay observation, isang araw na dalaw, question and answer sa mga personnel ng facilities na kanilang dinalaw and that's not enough po para sa kanila to figure out their future plans.	<i>right?</i> <i>Then most of the school cannot afford to send their students in their respective fields of interest, sometimes what just happens sir is observation, a day visit, question and answer to the personnel of the facilities they visited and that's not enough for to them to figure out their future plans.</i>
Okay	Aside from the 3Is, content of the subjects can be changed for the better with lessening the content and focusing more on the subject matter that is really needed. Kaya nga nakakatawa sir na meron tayong MELCs, sana ganyan kasi nasa sustainable development na tayo eh.. Sana po mapabilis na yung process kasi kaya naman pala lalo na ngayon sana maging stepping stone na natin siya para mabawasan ang content.	<i>Aside from the 3Is, content of the subjects can be changed for the better with lessening the content and focusing more on the subject matter that is really needed. That's why it's funny sir that we have MELCs, I hope that's how it is because we are in sustainable development eh .. I hope the process can be speeded up because that's why especially now I hope that will be our stepping stone to reduce content.</i>
Yes sir, MELCS	Kasi Sir kaya naman pala idecongest bakit andami andami. Ngayon ngang pandemic, isang competency isang topic isang linggo kaya	<i>Because Sir, it seems it could be decongested, why it's too many. This pandemic, one competency, one topic one week, it is</i>



How will you describe over all your teaching experiences in STEM Strand?	naman pala. Okay naman po Sir, masaya. Masayang magturo Sir sa field na masaya ka. Pati din student feeling ko nasasayahan din sa akin pag nagtuturo ako	<i>doable.</i> <i>It's okay Sir, happy. Happy to teach Sir in the field you are happy. As well as students, I feel they enjoy me when I teach</i>
Am I right sir that you said that it would also be better if the subjects could be reduced, then the 3Is if it could be extended	Yes sir sana para malengthen po experience nila.	<i>Yes Sir hopefully, to lengthen their experience</i>
In terms of skills sir, do you believe it is attained in STEM Strand?	Lahat nman ng skills sir nakukuha naman po.	<i>All the skills Sir were acquired</i>
If you could improve or change any aspect of STEM Strand, what would it be?	Yung mga nasabi ko po Sir okay naman na po	<i>All I mentioned Sir it is okay</i>
Finally, before we end this activity, is there anything else you feel I should know		



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about STEM Strand? I already have the accounts needed for my study. I hope you are still available if I need more elaboration of your answer in case I missed something. Thank you very much for your time and active participation.	I think I already said enough. Welcome, Sir Lexter.	



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APPENDIX Z

**INFORMATION VALIDATION FORM FOR TRANSCRIBED AND
TRANSLATED INTERVIEW**

I _____ of _____ and residing at _____
(name) (affiliation)
(address)

do hereby depose and state that:

1. Each transcript document submitted in satisfaction of the requirements for the research study “STEAM Education Framework for SHS STEM Strand,” is an authentic copy of the original, complete, and all statements and information provided are correct;
2. I was given the opportunity to add or change information on the translated transcript to correctly capture my perspective and viewpoints toward STEM Strand; and
3. In case of clarification and further explanation is needed based from the document and interview conducted, I will attest to the best of my knowledge that such changes made have undergone with my personal utmost verification and examination, so that the quality of the material shall not be unfavorably affected.

By affixing my signature in this form and in the interview transcript, I confirmed the veracity of the transcribed and translated interview and all the information therein.

Participant’s signature

Date



APPENDIX AA

SAMPLE INITIAL MANUAL CODING

1	
Interviewer Question	Interviewee Answer
Good day! I am Lexter R. Natividad. You can call me Lex. I am a PhD Science Education Student at the Philippine Normal University. Presently, I am working on my dissertation titled, "<i>STEAM Education Framework for Senior High School STEM Strand</i>." This is a study anchored on the grounded theory approach that aims to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Also, the study hopes to produce training design, indicators and standards as validation products of the framework. As a vital part of this academic endeavor, I am inviting you to a one-to-one interview session that will determine your needs and capture your constructs on STEM Strand which may inform the STEAM Education Framework. This activity will be recorded and you may answer in either English or Filipino whatever is convenient for you. Before we start, I would like to ask again for your consent to take part in this study. This activity will take one hour or more depending on your response. Do you have any question or concern before we proceed?	Yes, I give my consent. And so far, I have no question.



Okay, let's start.	
So Sir your full name is	XXXXXXXXX
Okay, your age	41 years old
Ahmm what pseudonym you want to use in this study?	Jordz
So your civil status is?	I am still single
And your place of residence?	I am residing here at XXXXXXXXXXXXXXXXXXXX.
Sir what is your undergraduate course?	I am a graduate of Bachelor of Secondary Education major in Mathematics at Central Luzon State University in year 2000.
And your master is?	I had my masteral at Nueva Ecija University of Science and Technology (NEUST). I took Master of Arts in teaching Mathematics. I graduated year 2013.
And foy your PhD Sir?	Right now, I am at the process of dissertation writing at the Philippine Normal University with the degree PhD in Mathematics Education
Sir what subject do you consider as your specialization?	



So sir overall your length of teaching experience, How many years?	Since I am a mathematics major in my undergrad, master and PhD, I believe my expertise somehow is teaching mathematics.
And then sir for STEM Strand, how many years na?	I already taught for 19 years.
And then what subjects you teach in STEM Strand Sir?	It's 4 years already Sir.
So its aligned in your specialization right?	I taught Basic Calculus and Pre-Calculus in STEM Strand
What do you think are your characteristics that qualify you to teach in the STEM Strand?	Yes Sir. I believe so.
	One of the characteristics that qualify me to teach in the STEM strand is my educational background. I believe. Again, I am graduate of Bachelor of Secondary Education major in mathematics and a graduate of Master of Arts in Teaching major in mathematics. Also I'm on my dissertation writing of my Doctor of Philosophy in Mathematics Education at PNU. Since Mathematics is one of the components of the

having good educational background



Okay so for you, qualifications and length of teaching experience. How about sir other qualifications?	STEM strand and with my educational background, I think I am qualified to teach STEM strand. Also, this is my 19 years of teaching junior high school mathematics and 4 years of teaching Mathematics for senior high school. I believe with that, I am qualified to teach in STEM Strand. Also, I believe that teaching for 19 years of teacher with passion, vision and dedication in teaching are also part of the qualification in STEM. And I believe that our primary reason why we are here is not for us to be rich but the knowledge that we will impart. As a good STEM teacher, I have to do materials suitable to the learning of my students. Basic needs like preparing power point presentations, making modules and also recording video lessons are the ways of deepening students learning. Attending my classes regularly and engaging in various seminars and trainings are also part of maintaining reputation as a good STEM teacher.	Teaching experiences Characteristics (passion, vision, dedication) knowledgeable always ready Continuing professional and personal growth



Sir lets go to the STEM Curriculum and design, What do you think of the STEM curriculum and design?	When I taught in my first year of teaching, basic calculus and pre-calculus, I found it <u>comprehensive</u>.	- Curriculum * comprehensive of the curriculum
Do you think the curriculum is comprehensive enough for the students?	Yes, because this is a one strand consisting of 4 components-Science, Technology, Engineering and Mathematics. Each component has subjects with various learning competencies to be learned by the students. I believe finishing this course will prepare learners to be at work or to be eligible to pursue higher education.	- STEM is preparative for learners
Let's go sir to the subjects you are teaching at STEM Strand, were you able to finish your syllabus every year?	With the passion I have, with the patience, I am trying to finish it. But sometimes because of the <u>limited time</u>, there are certain topics that are <u>sacrificed</u>. With the activities we had in the school, I can only <u>finish the major topics</u>.	- dedication - limited time - unfinished topics? - teaching most essential topics only
Ah ok	It is necessary to finish because it is difficult to get engineering and science courses for	



So do you think sir you were able to meet all the minimum competencies required by DepEd?	children if they did not get all in the STEM Strand. As if you were entrusted to do that, the children might say "Hello, we did not study it in senior high school" but it is in the curriculum so we need to finish.	trying their best to finish the subjects
Ah I see..	Yes in my case, some college students are grateful to me because they find the topics in basic calculus and pre-calculus easy to understand. I believe this is the manifestation that they got the skills needed in the STEM Strand.	appreciation
Does the present curriculum meet the objectives of the DepEd to produce students who will take courses in STEM fields?	You know when they say "Sir we use your hand out in pre-calculus and in basic calculus, we use it in college." It means, it was really helpful.	fulfillment?
	Yes, most of our STEM strand graduates are taking science, engineering and mathematics courses. They get it all. In our institution, it could. I don't know with other schools if they	meeting the objectives



Why do you think so?	really finish the curriculum or not.	
	Many of the STEM graduates are pursuing Science courses, Engineering courses and Mathematics courses. They find their courses are the fields needed in our society.	Seeing importance of their course → essential
But sir I heard that you said most. Are there any instances that the students did not take college courses related to STEM Strand?		
	Other STEM Students took Accountancy course.	Getting Non-STEM courses on college
Ohhh so like for ABM Strand, even though there is still Math in the course.		
	Yup.	
How about Sir textbook, materials for basic and precalculus, does DepEd provide?		
	CHEd has the materials. When we have the capability training last time, CHEd provided a textbook or course guide.	
Ohh, that is for CHEd, how about for DepEd, did you hear anything about their materials?		
	DepEd has materials for Grades 1 to 10 only.	limited materials



But in senior high school?	Nothing. But there are book makers but only for private publishers. I have seen books made by teachers. During our time, Pre-calculus is being taught for those college students who are taking BSEd major in mathematics in their third year or fourth year of college. So unlike today, you are going to teach the course or the subjects in the first year or second year college because SHS belong to first year and second year college. But I believe, with the technologies we have and the advance learning, teaching pre-calculus and basic calculus is suitable to their level right now.	lacking books suitable
Do you think Sir the topics for basic and precalculus are within the level of the capacity of the students?		
Also the topics?	Yup I believe, especially to those who are taking the STEM Curriculum. We are actually ready for these topics.	suitable topics
How about Sir in DepEd, what do you think?	They could teach with preparations of course. They have to prepare. Because the students in public schools is not that good especially if not coming from science	needing preparations



	curriculum. So the challenge there is how the students will learn those difficult topics. Although teachers could teach but the response of the students I think is in different way. That is something to consider.	student variability
On a scale of 1 to 10, how do you rate your overall knowledge in the STEM Subjects?	I am proud to say 8 only.	
Why do you say so?	I'm still lacking in doing some researches about mathematics education. Also, I have limited knowledge on technical aspects like technology integration in teaching mathematics.	research capability? lacking researches limited technological knowledge * essential in STEM/STEAM Education
Do you think you have sufficient preparation (in terms of technical, pedagogical, and content) to teach STEM subjects?	Satisfactory. Not so much in technical aspect.	
How about in technological?	I believe since powerpoint is used now, also video lessons, but with the other platforms and applications, I don't have that much. I believe I am not that much satisfactory.	limited knowledge on other computer applications



If you will grade yourself from 1 to 10 what is your grade?	I think 7 or 8.
How about in pedagogical?	I am very satisfactory. I think 9 but not.
Not surprising since from your teaching experience	Yes but also because of my masteral and doctoral, so I am confident enough with the pedagogy.
How about in content?	I think 9.
But do you believe that in terms of content, your knowledge is high enough?	I believe so. You need to be more knowledgeable that your students.
What other fields do you think are necessary in learning and teaching STEM?	I believe right now the missing courses is on environmental concern. Because of the floods, typhoon, pandemic, there is a need to integrate environmental concerns. Also, more on behavioral aspect on how to value these components (Science, Technology, Engineering and Mathematics) without compromising our care in the environment. Inclusion of environmental concern.

— sufficient pedagogical knowledge

— being knowledgeable

— integrating relevant subjects



Sir in teaching your students, what are the skills you want to instill?	In mathematics, the skills needed are <u>critical thinking and problem solving</u>. These are the primary goals. I believe with these skills will help them to be inquisitive, being a critical thinker when they are in their field of work, especially in making decisions. mostly 21st century skills
Do you think Sir they are creative?	They are creative but not in math. That skill is not enhanced in mathematics. But it follows, you also need creative thinking in mathematics. creative thinking
How about innovation? Are they innovative?	I believe in my subject because it is more on computation but I believe in other subjects, they are innovative such as in using computer software. innovation
How do you rate your content knowledge in each of these fields?	
How do you promote innovative, active, engaging, and collaborative learning in the class?	Satisfactory



How you group them Sir?	Formation of group learning as an avenue of collaboration in the class. I believe through this, I can promote innovative, active, engaging and collaborative in learning and teaching mathematics. There are different styles but such as auditory, visual, kinesthetic. Also, according to the ability like slow, fast, average learner. It also depends on their skills.	collaboration } differentiated instructions
How about reflective and critical thinking?	To promote reflective and critical thinking, we must be open to questions during discussions. We have to elaborate their thinking by entertaining their questions. Also, copying correct solution and answer after administering quizzes because when they commit mistake in quizzes, they have to know the reason why they make that mistake. And then for them to have good grades, they must know to summarize their scores at the end of the quarter. So that in the end, they know their weaknesses.	— openness — accomodating } timely feedback
How do you structure your teaching activities in STEM?	By providing questions that measure low order thinking skills to higher order thinking skills. I also provide them	



Sir are you traditional?	activities that will lead to the discovery of learning.	— inquiry-based activities
Do you find the STEM subjects difficult or problematic in any way?	In senior high school, it is not ideal to do the traditional. I am more inquiry based, more on asking questions. Also, more on concept-based.	inquiry / concept-based assessment
Why do you think so?	In my four years of teaching, no. However, students have concern on the style and pedagogy of some teachers. Though in other subjects.	? student's concern
How do you assess your students?	The subjects are programmed to suit the need and skills of a STEM graduate. And as long as you have compassion and patience to share your knowledge, I believe it's not difficult in any way. Because if they are having a hard time, you will have to adjust. So you will find means for them to learn that. You don't have to give up right away.	— dedication — perseverance in teaching
	It is based on DepEd Standards. They are assessed based on summative assessment components.	— policy-guided assessment



What are your criteria in the selection of assessment tools?	Same with Junor high school, they have written works, performance tasks and quarterly assessments.
But in your subject, you are more on?	Its more on the performance tasks.
What is the most common performance task in your subject?	Well, problem set. Its more on the applications of what we have learned. So that they could be prepared in their written work.
How did you establish students' consultation in class?	By giving my syllabus at the start of the school year. Schedule of consultation is reflected on the syllabus. This is one hour every day from Monday to Friday.
On what matter does the student consult you regularly Sir?	They are more on submission of late requirements and topics that they don't understand at the beginning. More on the subjects.

- performance-based assessment

- problem-based assessment

- allotting time for consultation

- subject-centered consultation



Learning environment is an important aspect in teaching. How do you promote and maintain safe learning environment in school?	Good ventilation and clean surroundings are my considerations to promote and maintain safe learning environment. It is difficult to teach when it is too hot in the classroom. Because without aircon, children can't solve because it's too hot. It affects them therefore it is important as well.	good physical learning environment
How do you effectively manage your students during class?	Proper seating arrangement and <u>silence</u> should be observed during class discussion but they are free to ask questions. It is not bad to ask. So, because the question somehow, develops critical thinking that can be acquired by learners.	strict classroom management promoting silence by good
Sir can you differentiate your classroom management with the SHS and JHS?	SHS students are silent. They are already mature. I can infuse in my discussion everything because they are quiet.	matured students • maturity



What support mechanisms have you received from your institution for your teaching?	Aside from the salary, Materials for teaching like projector and markers, trainings and seminars are the mechanisms that I received are very helpful in my teaching. <u>Because the learning of the teachers should be also continuous.</u>	Support in professional development
If you were an administrator, what support would you give to your teachers?	I will continuously give scholarships to the teachers. I will ask them to attend in seminars and training and engage them in some research project or work.	Continuing professional growth having research activities
What can you say about the SHS STEM Strand in general?	Very satisfactory because it has the competencies to prepare students for work and to pursue higher education related to their fields.	aligned competencies
So is it advantageous or disadvantageous to the students?	With respect to being competitive, it really improved. Very good indeed because they are being prepared. However, the transfer of the student for example from STEM Strand and then the course is	aligning STEM students to Non STEM Courses



How would you describe your overall teaching experience in STEM Strand?	accountancy. Alignment matters really.
If you could improve or change any aspect of STEM Strand, what would it be and why?	Very satisfactory. I continuously read books and engage in seminars and training to enhance content and pedagogy. I would integrate technology in teaching science, engineering and mathematics. This is done by having seminars and trainings on technology integration in teaching science engineering and mathematics. Inclusion of environmental concern on this strand is also necessary.
Finally, before we end this activity, is there anything else you feel I should know about STEM Strand?	I am just happy for being respondent in your study. So far, I think, I already impart all my perspective in STEM Strand.
I already have the accounts needed for my study. I hope you are still available if I need more elaboration of your	

continuous professional growth

integration of subjects

professional engagement training seminars

discipline integration



answer in case, I missed something. Thank you very much for your time and active participation.

Welcome, Sir Lexter.



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APPENDIX AB

CONTACT SUMMARY FORM
(FOR CONSTANT COMPARISON METHOD)

Name: xxxxxxx Date of interview: December 11, 2020
Pseudonym : Armier Time: 7:31 pm
Position: Teacher Date of Transcription: December 13, 2020
X Administrator
Type of SHS: Modality of Contact: X google meet
Public Integrated JHS – SHS zoom
Public Stand alone SHS face to face
Private SHS others pls specify:
X HEI with SHS
Private HEI with SHS

Date Coded: December 14, 2020

Note: Pick out the most salient points in the interviewee. Number in order on this sheet and note page number on which the salient point appears. Number point in text of write-up. Attach theme or aspect or code to each point in CAPITALS. Invent themes where no existing ones apply and asterisk those. Comment may also be included in double parentheses.

Page	Salient Point	Themes/Aspects/Codes
3	They must be graduate of science courses so that they can deliver the content. That should be the basic requirement. And if a teacher is a graduate of science course, we can expect him or her to be inclined with science teaching so everything follows.	BACKGROUND IN SCIENCE
3-4	Like enthusiasm, motivation to teach the course, and probably the passion, love for the subject. Those must be inherent to the teacher.	INNATE TEACHER'S CHARACTERISTICS
4	I really honor the parameters being used by the students when it comes to the performance of the teachers because they themselves are the end users of whatever engagement the teacher is doing in the classroom with them so I believe they are the best people to say whether a teacher is performing well or not.	GOOD TEACHER PERFORMANCE EVALUATION
5	Ideal in the sense that the competencies are there,	IDEAL



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	embedded in the curriculum design. However, there are some points that had been miscalculated in the sense that, it is projected to be within the capacity of the students but actually the students are way behind because they have yet been covered in the junior high school curriculum.	CURRICULUM/ ALIGNMENT OF TOPICS IN JHS AND SHS
5	But then, some time has still been projected over the basics so I think that time is wasted because it is just repetition of what has been taught to them when they are in Junior High School.	REPETITION OF TOPICS
6	Probably the inclusion of Arts if it would materialize would make the curriculum better.	INTEGRATION OF ARTS
6	If the school is capacitated enough to deliver the learning competencies required by the curriculum, I think so. Only that I think the present curriculum is too mechanical. It is too focus on the content and we know science to be technical and mechanical, not so often that we ask students to make a rap or song about the theory.	MECHANICAL/ CONTENT-FOCUSED CURRICULUM
8	Probably they share the same problem with the other science or non-science teachers out there who are not really technologically adept.	LIMITED TECHNICAL KNOWLEDGE
9	Because otherwise, we are really going to that direction that everything is becoming technical and I won't be surprised that we would be living like robots even in the educational system if we will not really touch the heart in terms of our teaching and learning.	HUMANIZING EDUCATION
10	It has become an obligation of the teacher to make the learning active and engaging. Because if they don't, we will not really expect a good product. The school really operates with that scheme. That is the teacher's main responsibility to deliver the lesson the	ACTIVE AND ENGAGING TEACHING



	way that it is engaging and that the students would become active learners.	
11	Although, it may also mean doing something from scratch which may also be related to being innovative but when you are innovative, you really put something different and maybe in some instances this innovativeness will lead to discovery of something. The emergence of something that has not been produce yet.	INNOVATIVENESS
12	Maybe their concern is more on how the delivery is done because we must admit the fact that teachers have their own strategies in delivering the lesson so there are instances where the students don't really appreciate how their teachers deliver the lessons so they have their concerns and when addressed, they still get what they have to get but anyway so that it being settled.	TEACHER FACTOR/ DELIVERY OF LESSON
13	Not really because we are really trying to claim the name of the school so we actually prioritize science materials especially when it come to purchase of materials so we really allocate funds for the purchase of the needed materials especially for science.	PRIORITIZING SCIENCE MATERIALS
14	We are also close to the exit and entrance in the University because we are near the main gate where the security guard are housed. One or two security guards are deployed to protect the vicinity of the school	PHYSICAL SECURITY
14	Our teachers are emotionally healthy enough, all of them. All of us are emotionally healthy and stable enough to deliver learning in an emotionally stable way.	EMOTIONAL SECURITY
15	My support mechanism is in terms of provision of resources. That's one. Because as the school head, I	PROVISION OF SUPPLIES AND



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	am the one in charge of the planning requesting, and purchase or procurement of the needed supplies and materials.	MATERIALS
16	Also, ensuring that they are well-rounded people that is giving opportunity for their mental health enrichment so that they will be healthy mentally, emotionally as well. That is why we are also holdings some rest and recreation activities in a regular basis so that we really can give time for our emotional well-being or mental health.	MENTAL AND EMOTIONAL SUPPORT
16	I also encourage them to attend seminars and trainings and conferences though they don't need much motivation on that aspect because they themselves are driven to capacitate themselves through this training, seminars, and conferences and I am 101 percent in support. So, I always approve their request to attend and even outside the country if they have the opportunity.	SUPPORT FOR PROFESSIONAL GROWTH
17	I know for a fact that there are teachers who are non-science but are handling science courses.	MIS-ALIGNED TEACHERS SPECIALIZATION



APPENDIX AC

LIST OF OPEN, AXIAL, AND SELECTIVE CODES DERIVED FROM THE INTERVIEWS

Open Codes	Axial Codes (Categories and Subcategories)	Selective Codes (Themes)
Expertise in subject matter Background in STEM fields Education graduate with major in science and math Graduate of science courses	<i>Aligned specialization</i>	Teachers' Qualifications
Graduate of a master's degree PhD holder	<i>Advanced degrees</i>	
Licensed teacher Board examination passer	<i>BLEPT passers</i>	
Enough experience in the profession Long years in teaching	<i>Sufficient teaching experience</i>	
Specialized skills Laboratory trainings Advanced skills in the subject	<i>Specialization training</i>	
Knowledgeable Mastery of the subject matter Have good content knowledge	<i>Subject Matter Competency</i>	Teacher Competencies
Updated to different trends Attends training and seminars Continuous learner	<i>Lifelong Learning Competency</i>	
ICT literate Technology integration	<i>Technological Competency</i>	
Being a researcher Research skills Knowledge in research	<i>Research Competency</i>	



techniques		
Verbal and non-verbal skills Good communicator Listening skills	<i>Communication Competency</i>	
Being a model and mentor Character flexibility Motivator and molder Motivated Critical thinker Innovative teacher Creative teacher Responsible Always ready and prepared Problem solver Committed Passionate Engaging Openminded Friendly Confident Have strong work ethics Flexible Commitment to teaching Love to students Enthusiastic Compassionate Willingness to change Empathic Have managerial skills Competent Giving effective feedback Have good performance evaluation Confident Have vision and dedication	<i>Social-Emotional Competency</i>	
Communication approaches Transmitting/communicating information	<i>Communicating Teachers</i>	
		Teacher Pedagogical Characters



Promoting student responses Explaining ideas Non-verbal and verbal teaching Making meaning Exploring ideas of students		
Active learning/participation Collaborative approach Social interaction Students' collaboration Cooperation Learning together Group activities Maximum participation in class discussions Sharing of ideas Students' enjoyment Engagement Gamification Student-centered Team-building skills	<i>Engaging Teachers</i>	
Experiential-based learning Critical pedagogy Discussion of community issues Reflective teachers Creativity in classrooms Real-life tasks Active discussions Authentic learning Critical thinking skills Societal importance of learning	<i>Transforming Teachers</i>	
Complete leaning standards Broad scope of the lessons Too much content Comprehensiveness of STEM Curriculum Complete subjects Articulation of curriculum Having specialized subjects	<i>Comprehensive yet congested</i>	STEM Curriculum refinement



Heavy in content Many competencies Repetition of topics Spiraling Number of subjects		
Work immersion Preparation for work environment Ambitious Entrepreneurship and employment Empowerment Equipping students Orientation for work Independence Ideal Skipping important lessons Allotting more time	<i>Work oriented yet very idealistic</i>	
Planned curriculum Preparation to college 21 st century skills Well-defined Logical Responsive to the societal needs of the society Challenges in teaching Enrolment in STEM-related courses in college Lack of learning and teaching resources Absence of textbook No chemical reagent No laboratory equipment Limited materials Lack of trainings in using lab equipment Lack of laboratory rooms	<i>Well-designed yet problematic</i>	
Values formation Character development Building positive behaviors	<i>Character Education Subjects</i>	Discipline-integration



Ethical concerns Right attitude Good manners and right conduct Religion subjects		
Medicine-related subjects Environmental concerns Absence of microbiology	<i>Other science-related courses</i>	
Incorporation of aesthetics Humanizing the curriculum Expressing creativity Inclusion of arts Complementing innovations Blending of arts	<i>Arts integration</i>	
Constant space for reflection Feedback mechanism Excellent work Cognitive faculties for career growth Accept and respect Exercise of rights Space for expression Ready for any issues Improving the facilities Support mechanism	<i>Sound Administration</i>	Administrator's leadership and management
Managing school resources and system Professional openness and honesty Recognizing teachers' diversity Democratic management Suggestive cooperation Managing teachers' performance Managing sustainable school programs and projects	<i>Effective Management</i>	
Coordinating educational connections	<i>Stakeholder Engagement</i>	



Establishing networks Building partnership with stakeholders Creating a culture of shared responsibility			
Acting on challenges and possibilities Maintaining integrity on work Managing personal effectiveness Participating in a professional development program	<i>Personal Excellence</i>		
Achieving the desired learning objectives Leading curriculum implementation Monitoring and assessing teachers undertaking Establishing learner-centered atmosphere	<i>Instructional Leadership</i>		
Making informative decisions Creating learning innovations Strategizing school's direction	<i>Innovative Strategic Thinking</i>		
Smart decisions Analytical thinking Practice cognition of thinking Thinking at critical level Deeper understanding Rational thinking Introspection Analytical thinking	<i>Critical Thinker</i>		Student's skills
Thinking outside of the box Intrinsically motivated Independent	<i>Creative</i>		
Real and practical intelligence Making connections Active learner	<i>Reflective</i>		



Examining learning		
Radical ideas Naturally curious Innovators Discoverers Builders	<i>Innovative</i>	
Collaborative approach Reflective questions Division wide-exam Written works Summative assessment Formative assessment Lower order thinking skills Higher order thinking skills Exit assessment Quarterly assessment Learning competencies	<i>Innovative assessment strategies</i>	Assessment practices
Role-playing Simulations Authentic assessment Traditional assessment Performance-based assessment Performance standards Content standards portfolio	<i>Assessment tools</i>	
Human factors Non-human factors Learning environment	<i>Environmental factors</i>	Safe Learning Space
Genuine respect Professionalism Sense of belongingness Emotions Caring Understanding teacher Enthusiasm	<i>Teacher's Affective Traits</i>	
Diversity and inclusivity Protection from violence No sensitive issues	<i>Classroom concerns</i>	<i>Classroom Climate</i>



No gender bias No discrimination			Policy Orientation and harmonization
Constructive feedback Classroom rules and procedures Monitoring of students Inculcating discipline	<i>Classroom Management</i>		
Presence of safety equipment Safety of building Security Structure soundness Working facilities	<i>Physical Environment</i>		
Provision of admission exam Readiness in STEM strand Additional requirement for admission	<i>STEM Entrance Examination</i>		
Changing of strands Transferring to another track Taking up non-STEM field Presence of shifters	<i>STEM students switching strands</i>		
Subject offerings of school Various schedule of subjects Transferring of students	<i>Harmonization of subjects</i>		
Misalignment of subjects with specialization Teaching subjects not their expertise Too many subjects Full workload Teaching effectiveness Expertise on subject matter	<i>STEM Teachers with many and mismatched subjects</i>		
Capable and competent teachers Teachers with license Qualified teachers Hiring guidelines	<i>Non-board passer teachers</i>		



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Teachers without professional license		
Capacity-building Enrichment programs Team-building activities Training Workshops Upskilling In-service training Learning Action Cell Online courses Resources Mental health programs	<i>Institutional support</i>	Partnership and Support
Collaboration with parents Parent-teacher association Donation of classroom facilities Brigada eskwela	<i>Parent Involvement</i>	
Establishing linkages Support from Local Government Units (LGUs) Partnership in work immersion Science agencies External laboratories Utilization of Special Education Fund Support from Non-governmental organizations (NGO) Alumni Politicians Financial assistance Crafting Memorandum of Agreement Creating Memorandum of Understanding	<i>Community Partnership</i>	



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APPENDIX AD

PROFILE OF VALIDATORS FOR FRAMEWORK, TRAINING DESIGN, AND SET OF INDICATORS AND STANDARDS

Validator 1

Name: **Niroj Dahal**

Affiliation and Rank: **Professor, Kathmandu University, Nepal**

Highest educational attainment: **PhD STEAM Education (Kathmandu University, Nepal)**

Specialization: **STEAM Education**

Validator 2

Name: **Roxanne T. Bongco**

Affiliation and Rank: **Professor, College of Education, Bataan Peninsula State University (BPSU)**

Highest educational attainment: **PhD Curriculum and Instruction (Philippine Normal University)**

Specialization: **Curriculum and Instruction**

Validator 3

Name: **Lalaine Ann F. Manuel**

Affiliation and Rank: **Assistant Professor, College of Education, Central Luzon State University**

Highest educational attainment: **PhD Curriculum and Instruction (cand) (Philippine Normal University)**

Specialization: **Curriculum and Instruction, Mathematics Education**

Validator 4

Name: **Arjay U. Rigor**

Affiliation and Rank: **Teacher III, Eduardo L. Joson Memorial High School, Quezon, Nueva Ecija**

Highest educational attainment: **PhD Science Education (Araullo University)**

Specialization: **Science Education**



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Validator 5

Name: **Gerald A. Quijano**

Affiliation and Rank: **Assistant Professor, College of Education, Nueva Ecija
University of Science and Technology, Cabanatuan City, Nueva
Ecija**

Highest educational attainment: **PhD Science Education (Nueva Ecija University of
Science and Technology)**

Specialization: **Science Education**



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APPENDIX AE

SAMPLE LETTER – REQUEST TO THE VALIDATORS FOR FRAMEWORK, TRAINING DESIGN, AND SET OF INDICATORS AND STANDARDS



Philippine Normal University
The National Center for Teacher Education
College of Graduate Studies and Teacher Education Research
Pedro Oneta Hall, Room 304 B, Taft Avenue, Manila



October 28, 2021

Dr. ROXANNE T. BONGCO
Faculty, College of Education
Batang Peninsula State University – Orani Campus
Orani, Batang

Dear Dr. Bongco:

Greetings from the Philippine Normal University!

I am a PhD Science Education student at the Philippine Normal University, Taft Ave., Manila and currently working on my dissertation titled, *"STEAM Education Framework for Senior High School STEM Strand"*. The goal of the study is to develop a STEAM Education framework for senior high school (SHS) STEM Strand. Sequentially, the study hopes to produce training design, indicators and standards as validation products of the framework. The study employed Strauss and Corbin (1990) grounded theory approach and the SHS science teachers in STEM Strand and their corresponding administrator were the participants.

In this regard, I kindly request your expertise and assistance in validating the developed STEAM Education Framework along with the training design and indicators and standards. The validation will utilize Delphi Technique. In this method, two or more iterations will be needed to improve and validate the developed framework. In the first round, the developed framework and the description of each component will be given to you. Your comments and suggestions will be elicited through the open-ended questionnaire. Afterwards, the second round of the Delphi technique will involve the questionnaire composing of statements answerable in a five-point Likert scale to express your agreement or disagreement to validate the revised framework. The comments from the first Delphi round and validation questionnaires in the literature will be the basis of items in the questionnaire of the second Delphi round. The same method will validate the generated training design and indicators and standards from the validated framework.

Attached are the description of the proposed framework, the instrument for the validator, and the approval of the PNU ethics committee on the conduct of my study for your perusal.

In appreciation for your invaluable help, a certificate of appreciation and a little token will be given to recognize your service and effort in fulfilling this study. I hope that you will find time out of your busy schedule to accommodate this request. Since my timetable is quite hectic, I also request to get back your evaluation within two weeks or earlier.

It is with high hope that I would merit your support in this endeavor through the approval of my request. Thank you very much and more power.

Very truly yours,


Dexter R. Natividad
PhD Science Education Student

Noted:

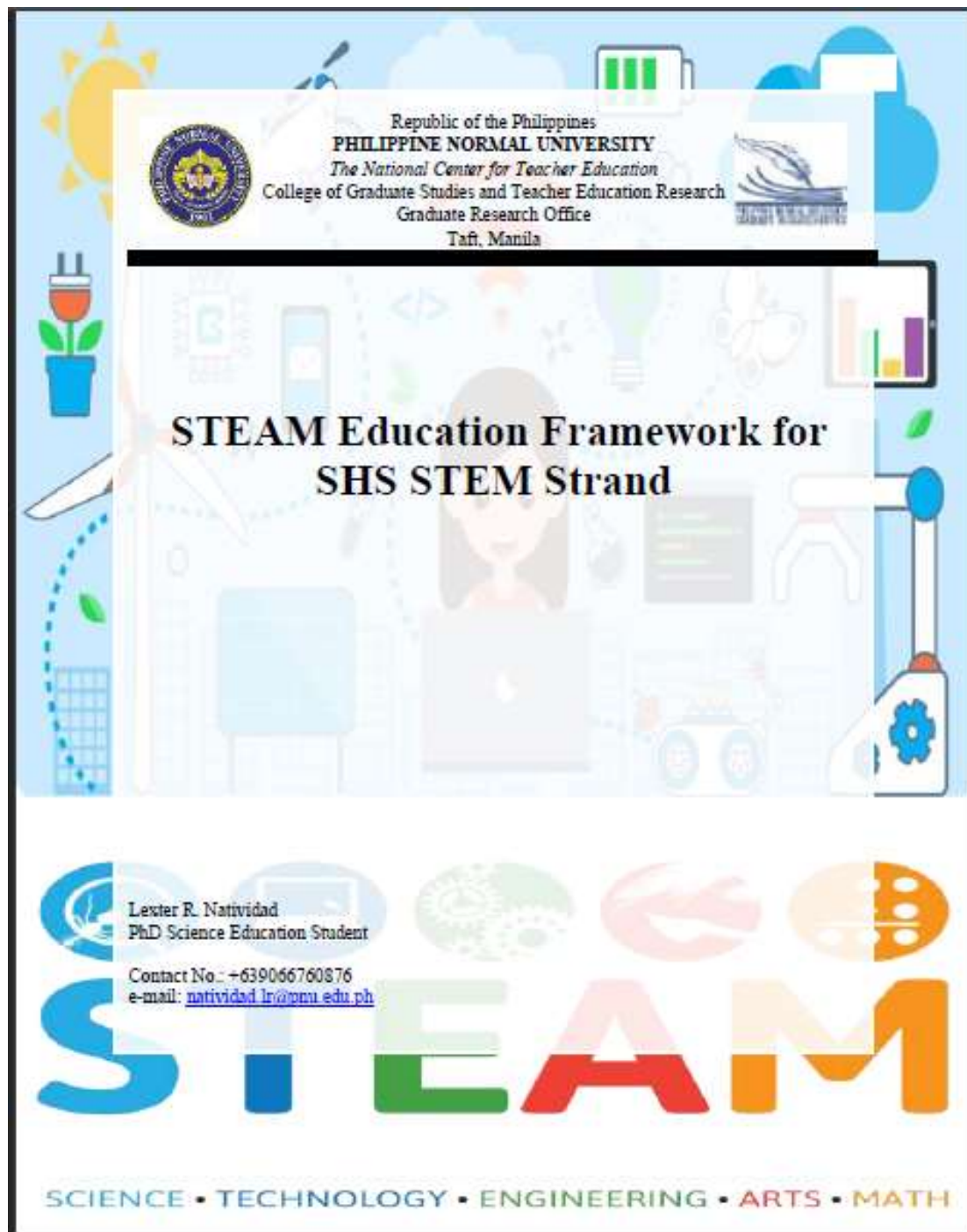

Marie Paz E. Morales, PhD
Advisor



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APPENDIX AF

THE FRONT MATTER AND TABLE OF CONTENTS OF THE PROPOSED FRAMEWORK GIVEN TO THE VALIDATORS





STEAM Education Framework for SHS STEM Strand

*Lester R. Natividad
PhD Science Education*

Table of Contents

Rationale	3
STEAM Education Framework	8
The Emergent Grounded Theory	9
Standards of the framework	12



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STEAM Education Framework for SHS STEM Strand

*Lester R. Natividad
PhD Science Education*



RATIONALE



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APPENDIX AG

THE QUESTIONNAIRE FOR THE FIRST ROUND OF DELPHI TECHNIQUE FOR THE VALIDATION OF PROPOSED FRAMEWORK



Philippine Normal University
The National Center of Teacher Education
Taft Avenue, Manila

Validation Instrument for the developed Framework

Name: _____ Date: _____

After reading the description of the framework, kindly answer the following questions.

1. What can you say about the principles, features, and components of the developed framework?

2. Can the framework be applied in a real-world setting? Please elaborate.

3. If you were to design the framework, what other principles, features, or components will you include?

4. What area(s)/component(s) of the framework do you feel that demand or need the most revisions?

5. Do you have any suggestions or comments for the improvement of the framework? Please provide the details.

Signature of the validator

Thank you for answering ☺



APPENDIX AH

THE SURVEY QUESTIONNAIRE FOR THE SECOND ROUND OF DELPHI TECHNIQUE FOR THE VALIDATION OF PROPOSED FRAMEWORK

Name: _____

Date: _____

Direction: This instrument is designed to validate and evaluate the proposed STEAM Education Framework for Senior High School STEM Strand. Kindly use the scale below to express your agreement and disagreement in each statement and put a checkmark (/) on the appropriate column based on your evaluation. If you have a rating below 4, please provide your comment or suggestion in the remark box.

Scale:

1- Strongly disagree

3- Neither agree nor disagree

5- Strongly agree

2- Disagree

4 – Strongly agree

Evaluation Criteria	5	4	3	2	1	Remarks
I. Content and Organization						
1. Each component of the framework is well described.						
2. The principles and elements of the framework are clearly discussed.						
3. The framework is easy to follow and understand.						
4. The framework adds to the body of knowledge.						
5. The framework is grounded on the situation of the SHS science curriculum in the country.						
6. The framework captures the desired outcome of what a STEAM Education should achieve.						
7. The framework is comprehensive.						
II. Relevance and Usability						
1. The framework can be used as a guiding framework for the STEAM Education rollout.						



2. The framework is relevant to the development of STEAM Education in Senior High School.						
3. The framework reflects the context of the future STEAM Education in the country.						
4. The Department of Education and other interested individuals can easily use the framework.						
5. The framework can be utilized in a science classroom.						
6. The framework is feasible to be implemented.						
7. The framework can possibly be adapted for different contexts or subjects.						
8. The framework is relevant to the Science curriculum.						
9. The framework is relevant to the current conditions and trends.						
10. The salient features of the framework are unique and relevant.						
11. The framework is doable and practical.						
III. Aesthetics and Presentation						
1. The framework is visually appealing.						
2. The principles and components are logically presented.						
3. The framework and its elements are clearly illustrated.						
4. The framework is logically sequenced.						
5. The presentation of the framework is understandable.						



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6. The language used is clear and easy to understand.						

Signature of validator



APPENDIX AI

THE RESULTANT FRAMEWORK FROM THE FIRST ROUND OF DELPHI TECHNIQUE





APPENDIX AJ

SUMMARY OF VALIDATORS' SUGGESTIONS AND COMMENTS FOR THE DEVELOPED FRAMEWORK AND THE RESEARCHER'S ACTION

Validation Question	Remarks	Revisions Made
What can you say about the principles, features, and components of the developed framework?	The framework is comprehensive. (Validator 1)	
	The framework captures the desired outcome of what a STEAM Education should achieve. Each of the principles, features, and components of the framework is aligned with STEAM Education. (Validator 2)	
	The principles, features, and components of the developed framework are complete. The developed framework reflects the context of the future STEAM Education in the country. (Validator 3)	
	The developed framework is tuned with the needs and current demands of STEAM Education at this present time. It deeply explained each element in the framework concerning the theory and practice of science teaching. (Validator 4)	
	The components of the framework are already grounded on what is happening in schools, hence the framework really reflects the situation. (Validator 5)	



Can the framework be applied in a real-world setting? Please elaborate.	Yes, it could be applied in the Philippine SHS setting if supported by policies, training programs, and resources. (Validator 1)	
	The framework can definitely be used as a guiding framework for the STEAM Education roll out as each of its components are the targeted goals to be achieved by STEAM. (Validator 2)	
	Yes, since the standards formed are really grounded on what is happening in the secondary education of the Philippines. (Validator 3)	
	The framework is doable and practical. (Validator 4)	
	Yes, the framework can be applied in real-context setting. (Validator 5)	
If you were to design the framework, what other principles, features, or components would you include?	This framework is quite impressive and holistic. However, I just noticed that it focuses on all the elements external to the learner (e.g. teachers, environment, admin, policies). This gives the impression that the outcome that we envision of STEAM learners is all about what is going to be done by the education sector TO them, not WITH them. (Validator 1)	The researcher explained to the validator that the developed framework is more of on implementation, thus, teachers, administrators, among others are the highlight in this framework.
	I think the feature and components of the framework	



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	are complete. (Validator 2)	
	The parts and details of the framework are already comprehensive, so I think I will not include any features anymore. (Validator 3)	
	In the current DepEd Framework, we have STEM without Arts because it belongs to Arts and Design Strand as an independent track. That is why the migration of Arts in STEAM seems challenging. Most science teachers have no background concerning arts. Therefore, training & support for teachers can be one of the main elements in the framework. (Validator 4)	A training design from the framework will be crafted.
	The framework is already complete. (Validator 5)	
What area(s)/component(s) of the framework do you feel that demand or need the most revisions?	I hope a standard for learners will also be incorporated so that STEAM education will be more of a learning engagement WITH them, rather than actions or policies applied TO them. (Validator 1)	The description for learners to become productive citizen was detailed in the framework
	Parental involvement and challenges that can be met in assessment practices. (Validator 2)	The description of the standards for assessment practices was elaborately written and in the discussion on the partnership and support.
	I think there is a redundancy wherein I read that it's all about standards for teachers such as teacher pedagogical characters,	The framework was modified such that standards for teachers were under one umbrella.



	teacher competencies, etc. I believe it can be revised that these standards will be under one umbrella. (Validator 3)	
	The framework is impressive as it tries to address the current problems and issues of science education here in the country. I have no more suggestions for revisions other than what I mentioned in my previous answer. (Validator 4)	
	The components already highlighted the needs that are contextualized in the Philippines thus I cannot suggest more. (Validator 5)	
Do you have any suggestions or comments for the improvement of the framework? Please provide the details.	It would also help to provide more specific description of what we envision on the art integration. (Validator 1)	The discussion of arts integration was made more specific on what the teachers and administrators were expected to do in this standard.
	Will there be a possibility that color continuity be made starting from the outside components to the inside? Can the components be re-arranged in such a way that each of them be aligned from one another? (Validator 2)	The components are rearranged as suggested. Color continuity for each component was also made.
	Since the outer circle represents the stakeholders such as parents and community, I suggest that the standards be categorized in each person involved, such as teacher and administrator, so that it is clear who is responsible for	The framework was revised such that the standards were under the specific stakeholders such as teachers, administrators, and policy and curriculum makers.



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	each standard. (Validator 3)	
	The main exit of SHS STEM students focuses on preparation for higher studies or to enter college education. (Validator 4)	
	I think the color of the framework should be made more vibrant to complement creativity, the focus of STEAM Education. (Validator 5)	The color of each standard was made more vibrant as suggested.



APPENDIX AK

THE QUESTIONNAIRE FOR THE FIRST ROUND OF DELPHI TECHNIQUE FOR THE VALIDATION OF TRAINING DESIGN AND SET OF INDICATORS AND STANDARDS



Philippine Normal University
The National Center of Teacher Education
Taft Avenue, Manila

Validation Instrument for the Training Design and Set of Indicators and Standards

Name: _____ Date: _____

After reading the description of the framework, kindly answer the following questions.

1. What can you say about the principles, features, and components of the crafted training design and set of standards and indicators?

2. Is the training design capable of preparing STEM teachers for the possible implementation of STEAM Education in Senior High School? Please elaborate.

3. Can the set of indicators and standards be used to assess the quality of STEAM education in Senior High School? Please elaborate.

4. Do the training design and the set of indicators and standards vividly elaborate the STEAM education framework? Please explain.

5. If you were to craft the training design and set of indicators and standards, what other principles, features, or components would you include?

6. Do you have any suggestions or comments for improving the training design and set of indicators and standards? Please provide the details.

Signature of the validator



APPENDIX AL

SUMMARY OF VALIDATORS' SUGGESTIONS AND COMMENTS FOR THE TRAINING DESIGN AND SET OF INDICATORS AND STANDARDS

Validation Question	Remarks	Revisions Made
What can you say about the principles, features, and components of the crafted training design and set of standards and indicators?	The principles, features, and components of the training design and set standards and indicators are well defined and captures STEAM well enough. (Validator 1)	
	The standards and indicators are very holistic and organized. The training design is very comprehensive and well-crafted. (Validator 2)	
	The training design and set of standards and indicators are comprehensive and complete. (Validator 3)	
	Indicators are well suitable in the present conditions of teachers in a classroom setting. The indicators are justifiable, comprehensive, and specific. It is justifiable because the identified needs are the real ones experienced by the teachers on the ground. It becomes comprehensive as the training designs offer a promising outcome. It tries to cover all the necessary elements that may affect in the development of the training. The training needs are presented with specificity as explained in particularity with suggested delivery, mode, and the number of hours. (Validator 4)	



	The crafted training design is effective in addressing the scenarios which are greatly overlooked by some of the administrators and teachers today. Each element manifests a thorough exploration and modification to guide the whole school community to make students pursue their own ideas and curiosities in the most challenging and productive way while learning and becoming a responsible citizen in line with how the STEAM curriculum was envisioned. The set of standards and indicators are good. They are sufficient to deliver the goals of this paper. (Validator 5)	
Is the training design capable of preparing STEM teachers for the possible implementation of STEAM Education in Senior High School? Please elaborate.	Yes, the training design will surely help prepare STEM teachers as the needed competencies and skills requirement of STEAM Education part and parcel of the training. (Validator 1)	
	Yes, it could. It offers a holistic and comprehensive view for implementation of STEAM education. (Validator 2)	
	Yes, the training design is capable of preparing STEM teachers for the possible implementation of STEAM Education in Senior High School since all the elements presented are towards to better understanding of the STEAM education and its processes. (Validator 3)	



Philippine Normal University

National Center for Teacher Education

	The training designs are well-crafted for STEM teachers, and using this in preparation for STEAM education would help achieve the program's objectives. The modules are logical as they start with the theory down to partnership with LGU and stakeholders, and in effect, it will support the teachers not only on soft skills but also hard skills. (Validator 4)	
	Definitely. The training design is contextualized where each component is coordinated to support the kind of educational structure on how STEAM curriculum and the broad spectrum of arts relate to the realities of school community as a whole. The design explains how all divisions of education and its workforce work in harmony for purposeful integration of the exploratory subjects which are critical in learner's development. The complete set of programs as per the paper show how it is adaptable, institutionalizes and reinforces standards in engaging and versatile manner. I believe that, the training design may help the education better. The model is functionally determined to increase the depth and breadth of proficiency of educators as they influence the global community through the advent of technologies and advanced interaction to support learners. I'm happy that the	



Philippine Normal University
National Center for Teacher Education

	framework has a living structure that represents a culture and open to all types of diversity. (Validator 5)	
Can the set of indicators and standards be used to assess the quality of STEAM education in Senior High School? Please elaborate.	Yes, indicators and standards set can be useful to assess the quality of the STEAM Education as it is well defined in accordance to the stipulated competencies and skill requirements needed by it. (Validator 1)	
	Yes they could. I only have reservations with the indicators for Arts integration. Isn't this incorporated to promote creativity among the learners? Would these indicators be enough to promote student creativity? The paper mentioned earlier that art integration is one part of STEAM education most teachers struggle with. So I guess this part should be more clear and explicit on how to promote student creativity through arts integration. (Validator 2)	The indicators for the arts integration were stated more explicitly and an additional indicator were also added to provide more clarity on how students creativity will be promoted.
	Yes, the set of indicators and standards can be used to assess the quality of STEAM education in Senior High School since it reflects the purpose of the STEAM education and is contextualized on what is happening in the field. (Validator 3)	
	The indicators have the impression that such can use to assess the quality of proposed STEAM Education. The indicators speak not	



	only during normal circumstances where face-to-face learning is allowed but also provide the necessary measures to maintain quality education even during the pandemic. It also tries to solve the limited laboratory and materials where quality education is not compromised. (Validator 4)	
	Definitely since the crafted standard and indicators are holistic in nature. (Validator 5)	
Do the training design and the set of indicators and standards vividly elaborate the STEAM education framework? Please explain.	Indicators and standards included vividly elaborated the STEAM Education Framework as the topics included in the training design clearly explained the contents and purpose of STEAM Education. (Validator 1)	
	Yes it does. They provide detailed standards and clear indicators for all aspects for successful implementation of STEAM. (Validator 2)	
	Yes since the training design content and the indicators are patterned and aligned and provide elaboration on the STEAM education framework (Validator 3)	
	Yes, the training designs are aligned and elaborated the indicators and standards of STEAM Education framework. The needs of the teachers on the frameworks were	



Philippine Normal University
National Center for Teacher Education

	answered and provided in the training designs and matrix. As mentioned in the previous number, training design was anchored with the needs of the STEM teachers, which are essential in the STEAM education framework. With the plans provided, the training becomes feasible, practical, and substantial. (Validator 4)	
	Yes. Generally, it provides numerous principles on how the education could be better by exploring its overlooked gray areas. The realities are well-discussed as to craft an adaptable learning structure for changing and unpredictable global development of education and curriculum. (Validator 5)	
If you were to craft the training design and set of indicators and standards, what other principles, features, or components would you include?	I will include the same principles, features, and components as they are already complete and comprehensive enough to capture the STEAM Education Framework. (Validator 1)	
	For the curriculum refinement/ policy standard, would it be possible to incorporate “safe” atmosphere for STEAM teachers to provide feedback or evaluation of the curriculum? Based on my own study, teachers feel hesitant to give feedback on the curriculum even when they feel it is not appropriate or working. Although technically, they are allowed to make reports on	An indicator incorporating “safe” atmosphere for STEAM teachers to provide feedback or evaluation of the curriculum is also added on the standard.



Philippine Normal University
National Center for Teacher Education

	feedback on curriculum, they feel that it is against the expectations. However, teachers being the frontliners in curriculum implementation, they know how this is operationalized so making them feel safe providing inputs might be important. (Validator 2)	
	The training design and set of indicators and standards are already comprehensive and complete. I will not add anything. (Validator 3)	
	Honestly, I am overwhelmed with the training designs. I have no more to say but to express my excitement about its implementation. (Validator 4)	
	I think they are all complete to cover the goals of the STEAM education in the Philippines. (Validator 5)	
Do you have any suggestions or comments for improving the training design and set of indicators and standards? Please provide the details.	I think the training design and set of indicators and standards are already comprehensive. Thus, I have no suggestion or comment anymore. (Validator 1)	
	I appreciate the recognition of andragogy and learning preferences or styles of target learners. However, reality on the ground shows that many schools are likely to simply interpret the “proposed” matrix as the standard or expected format for delivery. Hence, for the	The term “activity” was revised to “suggested activities” so that the training implementer will have a discretion on the activity they want.



Philippine Normal University
National Center for Teacher Education

	Table 3 (Proposed Training Matrix), would it be possible to simply merge the cells under each module and provide “Possible activities” and make the choice as broad as possible. This way, there would be a greater chance that learning style diversity will be considered in its implementation. (Validator 2)	
	Just like in the previous question, I have no suggestion or comments anymore. (Validator 3)	
	The indicators, features, and standards are all set in. I am praying and hoping that this framework will introduce soon. (Validator 4)	
	None. The training design and set of indicators and standards are already in order. (Validator 5)	



APPENDIX AM

THE SURVEY QUESTIONNAIRE FOR THE SECOND ROUND OF DELPHI TECHNIQUE FOR THE VALIDATION OF TRAINING DESIGN AND SET OF INDICATORS AND STANDARDS

Name: _____

Date: _____

Direction: *This instrument is designed to validate and evaluate the proposed training design and set of indicators and standards for STEAM Education Framework for Senior High School STEM Strand. Kindly use the scale below to express your agreement and disagreement in each statement and put a checkmark (/) in the appropriate column based on your evaluation. If you have a rating below of 4, please provide your comment(s) or suggestion(s) in the remark(s) box.*

Scale:

1- Strongly disagree

3- Neither agree nor disagree

5- Strongly agree

2- Disagree

4 – Strongly agree

Evaluation Criteria	5	4	3	2	1	Remark(s)
I. Training Design						
1. The training design is comprehensive and well-crafted.						
2. The objectives of the training are clearly defined.						
3. The training design is aligned to the training objectives and learning goals.						
4. The topics covered or modules in the proposed training are relevant for the participants.						
5. The module of the proposed training is organized and easy to follow						
6. The duration of the training in the training design is adequate.						
7. The training design is feasible to be implemented.						
8. The training design vividly elaborates the STEAM education						



framework						
9. The training design will help participants in the preparation of STEAM education implementation.						
10. The participants will learn from this training design if this is implemented.						
11. The participants will gain a deeper understanding of STEAM education and the validated STEAM education framework through the crafted training design.						
12. The training design offers a holistic and comprehensive view for implementation of STEAM education.						
13. The training design clearly encourages participation and interaction from the intended participants.						
14. The principles, features, and components of the training design are well defined and captures STEAM education well enough.						
15. Overall, the design of the training is satisfactory.						
II. Standards and Indicators						
1. The standards and indicators are holistic and organized.						
2. The standards and indicators are practical and substantial.						
3. The standards and indicators are clear and detailed.						
4. The standards and indicators are stated explicitly for their intended purpose.						



Philippine Normal University National Center for Teacher Education

5. The standards and indicators are justifiable, comprehensive, and specific.						
6. The principles, features, and components of the standards and indicators are well defined and capture STEAM education well enough.						
7. Standards and indicators are well suitable in the present conditions of the teachers and administrators in a school setting.						
8. The set of indicators and standards can be useful to assess the quality of the STEAM Education in the country.						
9. The standards and indicators vividly elaborate the STEAM education framework.						
10. The standards and indicators provide a glimpse on the possible contents and purpose of STEAM education for Senior High School.						

Other comments and suggestions:

Signature of validator



APPENDIX AN

CONSTRUCTS AND NEEDS EMANATED FROM THE INTERVIEW RESPONSES

<u>Instruction and delivery</u>	<i>Looking at the standards today in our classroom settings, I think I am not competent enough. In terms of the mastery of the subject and the teaching strategies, I lack of those. When we compare internationally, we can see in their teaching tools and strategy that we are lower enough as well as in competencies.</i>	Enhancement of teachers' content and pedagogical knowledge	
	<i>I let my students. I just let them suggest different things, because those kids are also mature. So every time they do experiments or do classroom activities even if they are just sitting, I give the outcome of the activity and they are the ones who suggest what they want to do there. For example Sir, in our Physics activities like parabolic motions. Instead of providing an improvised device, I let them suggest what they want to use to make a parabola. A lot of competence was checked right there. It's really very hands-on with that activity.</i>		Pedagogical strategies of STEM Teachers
	<i>But since they lack the prescribed licensure exam, they also lack pedagogy. It's really different if you are really a graduate of education and have a professional license, right?</i>	Need of licensed teachers	
	<i>In my class, I promote innovative, active, engaging, and collaborative learning in the class through groupings</i>	Development of students' skills	



	<i>in research by collaborative effort of each teammates in the group like in their thesis so that their skills will be developed. They are trained individually, but also in groupings when they consolidate their effort. Also, brain storming process so that they will think active and creatively and at the same time critically.</i>		
	<i>Add or replace some effective subjects. I hope also that teacher should teach subjects on their own expertise since some like are having a hard time to teach the subject not in my own field</i>	Alignment of subjects with specialization of teachers	
	<i>There are many subjects that I teach in the school. I hope that there will be limit in the subject you will teach.</i>	Deloading of teaching workloads	
<u>Feedback system</u>	<i>My support mechanism is in terms of provision of resources. That's one. Because as the school head, I am the one in charge of the planning requesting, and purchase or procurement of the needed supplies and materials. So since I am really in-charge, I made sure that I do have equity in terms of distribution though I must say I really give priority to the science courses because we are in the science high school. But I also see to it that some resources are allocated for the other courses, for the other subjects. Also, ensuring that they are well-rounded people that is giving opportunity for their mental health enrichment so that they will be healthy mentally, emotionally as well.</i>	Administrators' support	
	<i>"Well, how do I manage my teachers? For us, we take any endeavor as a learning opportunity. Every activity at school I look at, we look at as an</i>		Administrators' effective management



	<i>opportunity for me and my co-teachers to learn. We usually ask, what went right and what when wrong? And every time that is good so it is continued, with the good of course from there we learn and then the unsuccessful activities should not be repeated. That's how I deal with my co-teachers so from the SHS department. Whatever the feedback, it is always forwarded to higher authority so there's always two-way communication.</i>		
	<i>"Ah first we will provide if they need mentoring or coaching in teaching, then on the part of the admin, of course, we continue to improve facilities, purchasing of the equipment needed for instructions. For as long as the funds are available and allowed under MOOE so if there are no funds available, we will outsource if necessary. We do partnerships with different institutions if necessary, for instructions.</i>		Administrator leadership
	<i>Because most of our stakeholders, parents, understand us. They really understand the culture of what we have so well it becomes a support to us. Also, our principal is inclined in seeking for donations from politicians for science building so that drive of school administrators is good.</i>	Partnership with stakeholders	
	<i>I incorporate STEM into other afterschool activities and also, I use online resources to help develop a successful STEM experience.</i>	Innovative assessment strategies	
	<i>By providing questions that measure low order thinking skills to higher order thinking skills. I also provide</i>	Effective assessment tool	



	<i>them activities that will lead to the discovery of learning. In senior high school, it is not ideal to do the traditional. I am more inquiry based, more on asking questions. Also, more on concept-based.</i>		
<u>Learning environment</u>	<i>At the start of my classroom meeting, I set rules during and after class activities in which everybody knows what to do, how to do it and what not to do. I see to it that everybody in the class is feel comfortable during the discussion, they have to listen and ask questions if necessary, for confirmation or clarification.</i>		Classroom management
	<i>Last year, a building was constructed but not yet turned over because the previous principal did not sign the contract due to cracks and other concerns. However, due to limited classrooms, we are using the building.</i>	Safety of building	
	<i>We ensure that the equipment and laboratories are safe to be used by the students.</i>	Safety equipment	
	<i>I establish positive relationship or good rapport with my students. I acknowledge the uniqueness of each of my students.</i>		Diversity and inclusivity
	<i>We are also close to the exit and entrance of the University because we are near the main gate where the security guards are housed. One or two security guards are deployed to protect the vicinity of the school and so I believe in terms of security, at least in Physical security we ensured that.</i>	Security	



Philippine Normal University
National Center for Teacher Education

	<i>I assure that our class is free from any gender or racial discrimination.</i>	Free from discrimination	
Institutional support	<i>We provide a lot of support to teachers. I'll just enumerate some of the aspects. First is our support for professional growth and development. Every time we have the opportunity, we send teachers for training, seminars and then at school we do our own LAC sessions, Learning Action Cell Sir, then we encourage them to pursue graduate studies. So do I, I need to study as well.</i>	Needs of training, workshop and seminar	
	<i>The public schools need to collaborate to other science institution particularly in science related research institutions.</i>	Establishing linkages with community	
	<i>Our principal will create MOA and MOU for support with local government units and other organizations.</i>	Getting support from LGUs and NGOs	
	<i>Parents are very supportive, Sir. They are positive about our request like instance there was a time that I asked for approval of a project for the welfare of the students, they immediately approved it because they saw the benefit. They understand us.</i>	Parent collaboration	



Philippine Normal University

National Center for Teacher Education



CURRICULUM VITAE

1. **Name:** Lexter Ramuyan Natividad
2. **Date and place of birth:** 14 January 1989
Pob. East, Science City of Muñoz, Nueva Ecija, Philippines
3. **Mailing address and telephone number:**
University Science High School, Central Luzon State University,
Science City of Muñoz, Nueva Ecija, Philippines
044-456-0927
lexter_natividad@clsu.edu.ph
4. **Residence and telephone number:** Block 24, Lot 5, CLSU Village,
Bantug, Science City of Muñoz, Nueva Ecija, Philippines
0906-676-0876
5. **Civil status:** Single
6. **Educational background:**
 - Doctor of Philosophy – Science Education (PhD SciEd) [dissertation stage]
Philippine Normal University
Taft Ave., Manila, Philippines
2018 – present
 - Master of Chemistry
Central Luzon State University
Science City of Muñoz
Nueva Ecija, Philippines
2010 – 2013
 - Bachelor of Secondary Education (major in Physical Sciences)
Central Luzon State University
Science City of Muñoz
Nueva Ecija, Philippines



Philippine Normal University National Center for Teacher Education

2013 - 2015

- B. S. Chemistry (*Magna cum laude*)
Central Luzon State University
Science City of Muñoz
Nueva Ecija, Philippines
2005 - 2009
- High School Certificate (*Salutatorian*)
Muñoz National High School
Science City of Muñoz, Nueva Ecija
2001 - 2005
- Elementary Certificate (*Salutatorian*)
Muñoz South Central Elementary School
Science City of Muñoz, Nueva Ecija
1996 – 2001

7. Present position: Associate Professor V

University Science High School, Central Luzon State University,
Science City of Muñoz, Philippines. Taught high school
Chemistry, General Science, Earth Science, and supervised high
school researches in mathematics and other areas.

8. Professional Eligibility

- Licensure Examination for Chemists. September 27, 2010.
- Professional Board Examination for Teachers. November 15, 2015.

9. Research interests

- Natural Products
- Material Science
- Rice Chemistry
- Mathematics Education
- Science Education
- Crystallography

10. Distinction/ Honors/ Awards received:

A. IUCR Young Scientist Awardee given by International Union of
Crystallographers at Manila, Philippines on May 24, 2017.



Philippine Normal University
National Center for Teacher Education

- B. **One of the Great Men and Women of Science** given by International Biographical Centre, England (Great Britain) December 2015.
- C. **Outstanding Filipino Researcher 2015** given by Philippine Association of Institutions for Research, Inc. at Cebu City, Cebu, Philippines on October 28, 2015.
- D. **CLSU Outstanding Faculty (Level I)**, Central Luzon State University, April 12, 2014.
- E. **CLSU Outstanding Faculty (Level II)**, Central Luzon State University, April 12, 2018.
- F. **The Outstanding Young Novo Ecijano** given by Provincial Youth Development Council – Nueva Ecija and Office of Governor on September 2, 2014.
- G. **2014 Most Outstanding Coach of the Philippines (High School Category)** given by Association of Science and Mathematics Coaches of the Philippines at Boracay, Aklan, Philippines on October 24, 2014.
- H. **Floro Crisologo Award (Best in Oral Presentation)** given by University of Northern Philippines at Heritage City of Vigan, Ilocos Sur on April 29, 2015.
- I. **Best Oral Research Presenter in Science, Health and Technology** during the 2nd International Research Conference on Multidisciplinary Research at Cebu City, Cebu, Philippines at October 29, 2015.
- J. **Best in Powerpoint Presentation** during the 2nd International Research Conference on Multidisciplinary Research at Cebu City, Cebu, Philippines at October 29, 2015
- K. **2nd Place Best Poster**, CLARDEC Fiesta – 28th Regional Symposium on R & D Highlights, September 29, 2017
- L. **3rd Best Poster**, CLSU 28th Agency In-House Review of Completed and On-going R and D Projects, August 31 – September 1, 2016
- M. **3rd Best Paper**, ISSAAS PHILIPPINES 2016 National Congress and General Meeting, October 17-18, 2016



Philippine Normal University National Center for Teacher Education

- N. **Certified STEM Adviser**, National Training of Trainers on SHS STEM Education, April 18 – 20, 2017. UP NISMED, University of the Philippines, Diliman Quezon City.
- O. **Magna cum laude (BSChemistry)**, Central Luzon State University, 2009.
- P. **Adviser of the Best Student Thesis (Graduate Level/Masteral Degree)** 2018, Central Luzon State University.
- Q. **Adviser of the Best Student Thesis (High School Level)** for years 2014, 2015, 2016, and 2017, Central Luzon State University.
- R. **Dakilang Guro 2014**, College of Education, Central Luzon State University, October 3, 2014.
- S. **Best Student Teacher (Department and College Level)**, College of Education, Central Luzon State University, March 31, 2015.

11. Scientific and technical publications

1. Natividad, L.R. Deriving a formula in solving Fibonacci-like sequence. *International Journal of Mathematics and Scientific Computing* **1** (1): 19-21, 2011.
2. Natividad, L.R. On Solving Pell Means. *International Journal of Mathematical Archive* **2** (12): 2736-2739, 2011.
3. Natividad, L.R. Fibonacci Means and Its Applications. *International Journal of Mathematical Archive* **3** (3): 1087-1090, 2012.
4. Natividad, L.R. and Policarpio, P.B. A Novel Formula in Solving Tribonacci-like Sequence. *General Mathematics Notes* **17** (1): 82-87, 2013.
5. Natividad, L.R. On Solving Fibonacci-like Sequences of Fourth, Fifth and Sixth Order. *International Journal of Mathematics and Scientific Computing* **3** (2): 38-40, 2013.
6. Natividad, L.R., Astrero, M.F.T., Basinga, L.T. and Calang, M.K.G. Effects of Different Systemic Insecticides in Carotenoid Content, Antibacterial Activity and Morphological Characteristics of Tomato (*Solanum lycopersicum* var *Diamante*). *Asia Pacific Journal of Multidisciplinary Research* **2** (1): 209-213, 2014.



Philippine Normal University National Center for Teacher Education

7. Natividad, L.R. and Rafael, R.R. Carotenoid Analyses and Antibacterial Assay of Annatto (*Bixa orellana* L.), Carrot (*Daucus carota* L.), Corn (*Zea mays* L.) and Tomato (*Solanum lycopersicum* L.) Extracts. *Research Journal of Recent Sciences* 3 (3): 40-45, 2014.
8. Natividad, L.R. Notes on Jacobsthal and Jacobsthal-like Sequences. *International Journal of Mathematics Trends and Technology* 34 (2):115 – 117, 2016.
9. Natividad, L.R., Velasco, R.R., Dollente, D.J.M., and Abella, T.A. Benguet pine pollen (*Pinus kesiya*) as natural source of phytoandrogen. *International Journal of Biology, Pharmacy and Allied Sciences* 7 (6): 1121-1132, 2018.
10. Natividad, L.R., Baluran, S.M.D.L., Velasco, R.R., and Fernando, S.I.D. Determination of Pigments, Antioxidant Potential, and Vitamin Contents of Benguet Pine (*Pinus kesiya*) Pollen. *International Journal of Biology, Pharmacy and Allied Sciences* 7 (9): 1643-1651, 2018.

12. Consultancy/Technical Expertise

1. **Editor in Chief.** *Synergist*: The Annual Research Publication of University Science High School – Central Luzon State University.
2. **Associate Editor.** *The Social Prism*. The Annual Social Science Research Publication of University Science High School – Central Luzon State University.
3. **Technical Editor.** *Lukad: An Online Multidisciplinary Journal of New Literacies*. Philippine Normal University
4. **Project Staff/Study Leader.** Sustainable Research and Development for Agricultural Modernization and Food Security, Project 3: Phenolic Antioxidants and Colorants from Agricultural by-products for functional food and Cosmetics Applications.
5. **Technical Consultant.** Utilization of Modified Drip Irrigation for Production of High Quality Onion and Garlic.
6. **Chemist.** National Tilapia Research and Development Sub-Program A – Genetic Enhancement of Red Nile Tilapia, Project 3: Natural Carotenoids for Improved Growth, Body Composition, Feed Utilization, Immune Response and Fecundity of Red Tilapia.



Philippine Normal University National Center for Teacher Education

7. **Chemist.** Process Development of Onion Powder through Drum Drying Technology.

8. **Peer Reviewer**

- a. *Journal of Algebra and Number Theory: Advances and Applications*
- b. *British Journal of Mathematics & Computer Science*
- c. *Asian Journal of Mathematics and Computer Research*
- d. *Asian Research Journal of Mathematics*
- e. *JPAIR Multidisciplinary Research*
- f. *British Journal of Applied Science and Technology*
- g. *Journal of Basic and Applied Research International*
- h. *International Journal of Environmental Science and Toxicology Research*
- i. *Advances in Research*
- j. *Asian Journal of Current Research*

9. **Subject Area Teacher,** Plastic Usage Reduction: A School Campaign developed by UNESCO Bangkok, with support from the Japanese Funds-in-trust.

10. **Facilitator,** USHS Greening Project, National Greening Program, DENR-CENR Office.

11. **Facilitator,** Clean and Green, Waste Management and Segregation and Tree Planting Project of Barangay Bantug 2013-2015

12. **Cooperating Teacher,** CLSU Secondary Education Student Teaching Program 2nd Sem, AY 2015 – 2016 ; 1st Sem AY 2014 -2015

13. **Membership to organizations**

As Officer

1. Regional Coordinator, Philippine Organization of Mentors in Mathematics, Inc. (2015 – present)
2. Regional Chairman, Association of Science and Mathematics Coaches of the Philippines (2014 – 2016)
3. Regional President, Philippine Association of Teachers and Educational Leaders Inc. (2016 – 2018)
4. National Auditor, International Alliance of Mathematics Teachers Inc (2019 – present)
5. PRO, International Association of Mentors and Science Educators Inc. (2016 – 2018)



Philippine Normal University National Center for Teacher Education

6. Board of Director (Region 3), Philippine Institute of 21st Century Educators Inc (2018-present)
7. Secretary, CLSU Faculty Association Inc. (2016-2018)

Member

1. International Society for Southeast Asian Agricultural Sciences, Inc. (ISSAAS)
2. The Chemical Society of Japan
3. National Organization of Science and Technology Educators (NOSTE)
4. Philippine Society of Biochemistry and Molecular Biology, Inc.
5. Natural Products Society of the Philippines
6. Philippine Association of Chemistry Teachers, Inc. (Lifetime)
7. Mathematical Society of the Philippines
8. Integrated Chemists of the Philippines
9. International Carotenoid Society
10. Philippine Association for Teacher Education
11. Kapisanang Kimika ng Pilipinas
12. Philippine Association for the Advancement of Science and Technology Inc.
13. Philippine eLearning Society
14. International Association of Scholarly Publishers, Editors & Reviewers, Inc.
15. Asian Society of Teachers for Research
16. Philippine Association of Institution for Research, Inc.
17. Association of Scholarly Peer Reviewers
18. Science Club Advisers Association of the Philippines
19. Chess Arbiters Union of the Philippines
20. Graduate Education Association of Chartered Colleges and Universities of the Philippines (GEACCUP), Region III
21. State Colleges and Universities Faculty Association of Region 3, Inc.
22. Confederation of Faculty Association of State Colleges and Universities of the Philippines Inc.

14. Scientific/technical conferences/seminars attended

As coordinator/organizer

- March 13 – 14, 2021 *International Graduate Teacher Education Summit 2021*
Philippine Normal University
- December 6 – 8, 2018 *Seminar – Workshop on 21st Century Science Teaching Pedagogy*
Marikina City, Philippines



Philippine Normal University National Center for Teacher Education

- October 12, 2012 *Science Researches in the 21st Century*
Central Luzon State University, Science City of
Muñoz, Nueva Ecija

As Resource Speaker

- September 24 – 26, 2020 *Lukad Virtual Conference 2020*
Philippine Normal University
- September 11, 2018 *Raising the bar of Excellence in Science*
Investigatory Project
Our Lady of Sacred Heart of Guimba, Inc. Guimba,
Nueva Ecija
- August 1 – 4, 2017 *Seminar-Workshop on Latest Trends in the*
Pedagogy
University Science High School, Central Luzon
State University
- May 29 – June 2, 2017 *STEM Education Training Program – Regional*
Rollout
Hotel Stotsenberg, Clark Freeport Zone, Pampanga
- November 17-19, 2016 *21st Seminar Workshop of Philippine Association of*
Chemistry Teachers, Inc.
Theme: Chemistry Education and Research: Strong
Foundation for the Country's Growth and
Development
Subic Bay Travelers Hotel and Event Center, Subic
Bay Freeport Zone
- April 22, 2016 *The Researcher in You: A Seminar on the Essentials*
of Research for Development
CLSU, Science City of Munoz, Nueva Ecija
- March 4-5, 2016 *Training Workshop in Conducting Investigatory*
Science Project
Baybay City, Leyte
- August 13, 2015 *One-Day Seminar-Workshop in Science*
Investigatory Project
San Jose City, Nueva Ecija



Philippine Normal University

National Center for Teacher Education

As paper presenter

- December 1 – 2, 2018 *National Conference on Science, Technology, and Mathematics Education 2018*
Geronima Pecson Hall, Philippine Normal University, Manila

Title of paper: Students' Plagiarism in a Specialized Science Senior High School: An Account of Understanding, Grade Level, and Sex Differences.

- January 24 – 26, 2018 *2018 National Research Conference and Teachers' Convention*
Punta Villa Resort, Arevalo, Iloilo City, Philippines

Title of paper: Carotenoid Analyses and Antibacterial Assay of Annatto (*Bixa orellana* L.), Carrot (*Daucus carota* L.), Corn (*Zea mays* L.) and Tomato (*Solanum lycopersicon* L.)

- January 24 – 26, 2018 *2018 National Research Conference and Teachers' Convention*
Punta Villa Resort, Arevalo, Iloilo City, Philippines

Title of paper: On Solving Fibonacci-like Sequences of First to Sixth Order

- October 17-18, 2016 *ISSAAS 2016 National Congress and General Meeting*
Philippine Carabao Center, Science City of Muñoz, Nueva Ecija

Title of paper: Total Phenolic Content and Antioxidant Activity of Select Agricultural By-Products

- October 17-18, 2016 *ISSAAS 2016 National Congress and General Meeting*
Philippine Carabao Center, Science City of Muñoz, Nueva Ecija



Philippine Normal University National Center for Teacher Education

Title of paper: Development and Validation of Rapid Amylose Test Kit

- October 27-30, 2015 *2nd International Conference on Multidisciplinary Research*
Quest Hotel and Conference Center, Cebu City, Philippines

Title of paper: Carotenoid Analyses and Antibacterial Assay of Annatto (*Bixa orellana* L.), Carrot (*Daucus carota* L.), Corn (*Zea mays* L.) and Tomato (*Solanum lycopersicon* L.)

- April 27 – 29, 2015 *3rd National Multidisciplinary Research Conference*
University of Northern Philippines, Heritage City of Vigan, Ilocos Sur

Title of paper: On Solving Fibonacci-like Sequences of Fourth, Fifth, and Sixth Order

- March 14, 2014 *1st National Research Conference on Arts, Sciences and Health*
Lyceum of the Philippines University, Capitol Site, Batangas City

Title of paper: Effects of Different Systemic Insecticides in Carotenoid Content, Antibacterial Activity and Morphological Characteristics of Tomato (*Solanum lycopersicon* var *Diamante*)

- March 7, 2013 *2013 National Engineering and Science Research Conference*
Heritage Hotel, Roxas Boulevard, Pasay City

Title of paper: A Novel Formula in Solving Tribonacci-like Sequence

- August 28, 2009 *2nd CAS Research Conference*
College of Arts and Sciences, Central Luzon State University, Science City of Muñoz, Nueva Ecija



Philippine Normal University National Center for Teacher Education

Title of paper: Development and Validation of Rapid
Amylose Test Kit

As poster paper presenter

- April 13-15, 2016 *31st Philippine Chemistry Congress*
Iloilo Grand Hotel, Iloilo City
Philippines

Title of paper: Total Phenolic Content and Antioxidant
Activity of Select Agricultural By-Products

- July 26 , 2012 *Inter-Regional Research Conference on the
Sciences, Technology, and the Arts*
Central Luzon State University, Science City of
Muñoz, Nueva Ecija

Title of paper: On Solving Pell Means

- February 17, 2012 *2nd International Research Conference*
College of Arts and Sciences, Central Luzon State
University, Science City of Muñoz, Nueva Ecija

Title of paper: Development and Validation of Rapid
Amylose Test Kit

As facilitator/Parallel Session Moderator

- January 24 – 26, 2018 *2018 National Research Conference and Teachers' Convention*
Punta Villa Resort, Arevalo, Iloilo City, Philippines
- September 9, 2017 *GrubStreet 2017*
University Science High School, Central Luzon
State University, Science City of Muñoz, Nueva
Ecija
- May 7 – 11, 2012 *National Teacher Training on the Implementation
of*
Grade 7 of the K to 12 Basic Education Curriculum
College of Education, Central Luzon State
University, Science City of Muñoz, Nueva Ecija