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**Development and Validation of Performance Tasks on
Mathematical Modeling**

A Thesis
Presented to
The College of Graduate Studies and
Teacher Education Research
Philippine Normal University

In Partial Fulfillment
of the Requirements for the Degree of
Master of Arts in Education
with Specialization in
Mathematics Education

by

Vanessa P. Pangan

June, 2020



APPROVAL SHEET

This thesis entitled "**DEVELOPMENT AND VALIDATION OF PERFORMANCE TASKS ON MATHEMATICAL MODELING**" prepared and submitted by **VANESSA P. PANGAN** in partial fulfillment of the requirements for the degree of **Masters of Arts in Education Major in Mathematics** is hereby recommended for approval and acceptance.

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And above all to Him. The all-knowing God and ever-present God, who never ceases to provide strength, guidance, love, peace, hope and provider of Infinite blessings, I offer this glory to You, I offer this glory to You. This will never be possible without You. You are my salvation and shoulder to lean on when I felt on giving up.

Vanessa P. Pangan



Dedication

This simple fruit of my labor is humbly dedicated to my inspirations in life who gives me strength and determination to fulfill my dreams, no other than my parents and the Lord our Savior, the source of wisdom, eternal peace and happiness.

Vanz

God chooses what we go through;
We choose how we go through it.
I can do all things through Christ
Who strengthens me.

Philippians 4:13



ABSTRACT

Name : Vanessa Pingol Pangan

Title : **DEVELOPMENT AND VALIDATION OF
PERFORMANCE TASKS ON
MATHEMATICAL MODELING**

Key Concepts : **Authentic Assessment
Performance Tasks
Mathematical Modeling**

Degree : **Master of Arts in Education
with Specialization in Mathematics**

Adviser : **Rosie L. Conde, Ph.D.**

The study aimed to develop and validate a performance tasks on Mathematical Modeling in Junior High School Algebra. Design and developmental method of research was used in this study with the aid of an expert's validation checklist as data gathering instrument. To develop a performance tasks on Mathematical Modeling (MM), a modified instructional model (IDM) was utilized that included preparation, development, validation and try-out stage. In the preparation stage, the researcher identified the competencies to be included from the Mathematics curriculum set by the Department of Education (DepEd). In the development stage, the researcher identified the type of Mathematical Tasks used that elicit MM skills. In the Validation stage, there were two phases of validation. In the first phase of validation, the pools of critics were two Math experts from Philippine Normal University and three from the DepEd-Pampanga and in the second phase, there were three Math experts from the DepEd-Pampanga who assessed the developed performance tasks. Likewise, in the try-out stage, there was an initial and final try-out of the material to Grade 10 students from SY 2018 – 2019 and 2019 – 2020 respectively. Arithmetic Mean, Standard deviation and rating scale were used to analyzed the obtained data. The study concluded that the developed performance tasks on MM were valid and useful based on the experts' validation. In addition, the developed performance tasks were integrated with the 6Cs, six principles of Galbraith and three approaches of MM by Galbraith. This means, it can contribute to the achievement of specific objectives, provides for the development of higher cognitive skills, is well-organized and well designed and suitable to the ability of the students.



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Chapter I

The Problem and Literature Review

Mathematic matters in everyday life. In the modern world that we have today, it is significantly relevant to use math in solving multiple problems be it physical, biological and even sociological. Chevellard (2014) described Mathematics as a human activity, a social phenomenon and a set of methods used to help illuminate the world. It gives us ways to understand patterns, quantify relationships and sometimes even predict future.

In school setting, teachers of Mathematics work with students of all ages with the goal of helping them develop critical thinking abilities by understanding mathematical concepts. To check if the said goal is met, assessment is done. Assessment as defined by Barber, Donnelly, Saad and Lawrence, (2013) is the process of gathering and discussing information from a multiple and diverse source in order to develop a deep understanding of what the students know, understand and can do with their knowledge as a result of their educational experiences.

In a mathematics class set up, Claxton and Lucas (2009) stated that assessment is always done either of worksheets, exams or board works and focused on computations and solving word problems. Unfortunately, this kind of assessment is viewed negatively by the learners for it is considered as traditional. The educational system's obsession with traditional method of assessment consisted of paper and pencil activities has damaged teaching and learning by putting too much importance with concepts memorization and recalling facts, prompting that there is always only a single answer to every problem (Ganyaupfu, 2013). This statement is also supported in the finding of Claxton and=PO



Lucas (2009) when they emphasized that students need to learn not only school skills for this is considered insufficient to equip students to be life-long learners and active participant of the world. Meanwhile, Suurtamm et al. (2016) declared that traditional assessment in Mathematics focuses only on low-level facts, repetition of the step by step procedures and routine skills. Therefore, the use of traditional assessment in Mathematics is misleading the mind of the learners that Math is solely focused with problem solving and calculation (Pepper, 2011). For this reason, students started now to perceive mathematics negatively as one of the subjects taught to them in school.

For this reason, it is now the job of mathematics teachers to change these perceptions by giving the learners the original sense of living Mathematics by providing Mathematical task that illuminates and expresses relationships and ideas in numerical, graphical, symbolic, verbal and pictorial forms. To exhibit Mathematical competence, a teacher should implement tasks which are anchored and aroused the Math curiosity of a child which is believed to be the basis of the K to 12 curriculum, by DepEd order no. 8 s. 2015. Based from the said order performance task now takes a huge part on the assessment of the learners. In particular, 40% of the assessment in Mathematics is from performance task. This means that the students are asked to apply what they have learned in ways that reflect real – world uses of knowledge and skills.

Performance assessment is not solely focused with the responses of the learners but on the process of how the learners come up with their answers (Pellegrino, 2013). It is where the learners started to understand multiple learning dimensions instead of only having single correct answer. It was also stated that performance assessment allows



learners to demonstrate their talents and skills with the expectation that it will be done accurately and independently.

Performance assessment as defined by Woolfolk (2010) is an assessment that enables students to demonstrate their knowledge and skills in real life context. Compare to the traditional assessment which emphasizes what students know, performance assessment is designed to evaluate what students know and can do that reflects real-life situations which are significantly important to understand and value. He emphasized further that through the use of performance task as a basis for students' performance, students will now be able to understand that Math is not only about formulas and complex lessons but also a subject that can be applied in real life.

Performance task in Math should not be just a replica of real life but be life itself to showcase its importance (Stacey & Turner, 2015). It should require the use of higher order thinking skills. Thus, Mathematical tasks should be activities in which students become engaged in determining not only what substance they learn but also how to think about, develop, use and make sense of Mathematics and one of which is Mathematical Modelling (MM). Mathematical Modelling is where students can learn Mathematical concepts while solving real – life problem that requires Mathematical competence.

Vos (2013) defines MM as solving complex problems parallel to real world situations. Real world means the place in which one such as the learner actually must live and the circumstances with which he or she must deal. National Council of Teachers in Mathematics (NCTM, 2016) stated that MM is the process of using representations to represent real - world situations. Furthermore, the Guidelines for Assessment and Instruction in Mathematics Modeling Education (GAIMME, 2016) defines MM as a "process



that uses Mathematics to represent, analyze, make predictions or otherwise provide insight into real world phenomena. Moreover, MM involves identifying and selecting relevant features symbolically, analyzing and reasoning about the model and the characteristics of the situation, and considering the accuracy and limitations of the model. Thus, real world application and representation of Math ideas and concepts is a part of Mathematics learning and Math modeling is the catalyst to promote Mathematics as a representation of real life (Oswalt, 2012). Therefore, the performance task in Math can be in the form of MM that represents life and uses higher order thinking skills. Traditionally, MM is being used in higher, pure and applied Mathematics to solve real world problems (NCTM, 2016). But with the emerging need to uplift the academic performance of the learners in Mathematics, the use of MM in High School is encouraged.

The Algebra Standard of Principles and Standards for School Mathematics by NCTM (2016), mentioned that high school learners are expected to learn how to use Mathematical models to represent, solve and make connections on real world problems. Learners should be assessed not just by exams, but should encounter real world problems they can solve through Math modelling as well. Furthermore, MM provides an opportunity to explore Math in real life context which plays a vital role in the Mathematics classroom. Using Mathematical modeling, learners experience the real meaning of Mathematics that enables them to represent, communicate, reason, make connections and solve problems.

Researches, however in this field of MM involving students in junior high school have been few (Hesteness, 2013). In the Philippines, there are only few known researches on MM which has been carried out among Junior High School Students. The study focused on developing performance task using MM because its integration into everyday life at



school is necessary to inculcate in the mind of students that Mathematics can be incorporated with reality. Moreover, the researcher wanted to give awareness to teachers about MM since it is not yet a practice integrated into day to day classroom discussion so far.

Literature Review

The emerging used of performance assessment task in Mathematics, particularly Mathematical Modeling (MM) has been an unknown path since now. The researcher collected related literature and studies to give clear understanding with performance task on MM and its implication in the academic performance of the learners.

Assessment

Assessment is an integral part and parcel of instruction that enhances, empowers and celebrates student learning (Rosaroso & Rosaroso, 2015). Celebrating the learning acquired by the students is more than a display of their work for it also reflect on what they have learned, how they learned, questions they answered and areas of their strengths and knowledge. It is a task that provides evidences upon which subsequent feedback, decision, predictions or placements are based. Tillema (2014) defines assessment as a process involving students' performance to test whether learning takes place inside the classroom. Likewise, Russel and Austin define assessment as the process of gathering data to support a claim or understanding about the students from which the data was gathered.

Assessment can be categorized into two types; traditional and authentic. Traditional assessment is also known as "paper and pencil tests" which is single response type of



assessment such as multiple choice and true or false test. While, authentic assessment is based from real life context with multiple answers (Webb, 2012).

Traditional assessment is a standardized testing that uses questions with limited number of choices such as Multiple-Choice Test and True or False Test. Corpuz and Salandanan (2015) stated that Traditional assessment provides only one type of information about learners' achievement. It is only answering one question and that is "what they know?" Furthermore, it is considered lacking real - world context. It lacks chances to demonstrate learners' knowledge and skills.

On the other hand, William (2011) stated that authentic assessments are replica of real-life problems that involves construction of knowledge and demonstration of skills. It means of evaluating a learners' knowledge and skills in real-life context. It requires learners to solve real-life problems or to demonstrate skills or develop a project such as portfolio and performance assessment.

The ultimate goal of assessment is to help develop independent, active and lifelong learners who can monitor and assess their own learning and provide opportunities for learners to express their opinions (Rankin, 2015). More so, assessment provides teachers data to compare the previous performance of the students to the present. It will be a basis for a teacher on what next step he/she should provide to make learning successful. Consequently, it is an avenue for students to build confidence, develop ownership of their learning and increase their knowledge and skills (Witte, 2012).

Norris (2009) enumerated three reasons why assessment of learning is important. First, it helps to clarify goals and objectives and can serve as a means of improving



instruction and learners' effort. Second, it is the basis of teachers' feedback to the learners. Third, it increases the awareness of the teacher, parent and learner itself to their progress.

Effective assessment practices are essential to support Mathematical learning. This means that without effective assessment, it is impossible for everyone involved in the teaching and learning process to determine if learning took place or not. Thus, assessment should be engaging, interesting, and meaningful and promote learning (Hartman, 2017).

Conversely, Santrock (2009) argued that if assessment is not part of the teaching and learning process, then the instruction is just a teacher centered activity that lacks learning impact and attainment of desired outcomes. It can be used to support the result in improving students understanding and ability to apply knowledge.

According to Swan and Burkhardt (2012), assessment in Mathematics should reflect its importance and application in real life. Therefore, classroom assessment should take into account not only content but also mathematical application, practices, processes and competencies but also opportunities for all students (Klinger, et al., 2015).

Performance Task

According to Pellegrino, Wilson, Koenig, and Beatty (2014), the era of traditional assessment or commonly known as "pencil and paper", as the form of assessment has long been gone. This type of assessment has damaged the teaching and learning by putting too much value on recalling facts and memorizing formulas, prompting the misleading impression that there is a single right answer for every problem or question, turning students into passive learners who are solely relying with the information the teacher provides.



Performance Task on the other hand is an authentic form of assessment that replicates real-life situations to be solved by the learners as mentioned by Bree and O'Shea (2010). Performance task as a set of strategies for the application of knowledge and skills in a performance tasks that are meaningful and engaging and it includes emphasis on real – world situations. This type of assessment provides information to the teachers about what and how learners process and apply information. Similarly, Bostic and Jacobbe (2010) define Performance task as an assessment tool that measures learners' ability to demonstrate knowledge and skills by requiring learners to develop their original responses for it requires learners to use higher-order thinking skills to create a product or to complete a task.

Authentic Assessment task is designed to align activities that have sense of realism and address real world problems (Salandanan, 2012). The heart of authentic assessment is realistic performance based, asking students to use knowledge in real world ways.

Basically, performance task is an authentic assessment that is designed to simulate or replicate important real-world challenges. Hence, through Performance, Math becomes more real and more significant to the learner (Shehadeh, 2012). It is emphasized that Performance task is authentic in nature, wherein learners are asked to transfer what they have learned in a new and realistic situation

Darling-Hammond (2010) listed the advantages of Performance task; (a) It is more authentic in nature; (b) It prompts the use of higher order thinking skills instead of memorization and imitation; (c) It is promotes student engagement and interest; (d) It is more valid since it measures learners' knowledge and skills; and (e) supports higher quality teaching and learning. With a Performance task type of assessment not only is the answer



of the learners is being evaluated but also the process on how they come up with their answers.

Researches over the years made it clear that Performance task has a positive impact on the teaching and learning process. A study conducted by Malinao (2015), which assessed the effectiveness of Performance task on the achievement of Grade six pupils in Mathematics, showed that there is a significant difference in the academic performance of the pupils after the implementation of performance-based assessment tasks. Moreover, it is revealed that performance task is more effective than the traditional method of assessment which is also known as paper and pencil assessment task. This implies that teachers should stop using the conventional type of assessment and start moving forward to a more innovative way of assessment that requires students to use Mathematical competences. As Rosaroso and Rosaroso (2015) examined the use of Performance task in selected higher education classrooms in Cebu City, results revealed that through performance-based assessment tasks, students became more motivated to learn with persistence. Not to mention that the learners were able to socially interact and learn from one another.

Arhin (2015) in his study "The Effect of Performance Assessment-Driven Instruction on the Attitude and Achievement of Senior High School Students in Mathematics in Cape Coast Metropolis, Ghana" found out that Performance task driven classroom demonstrates stronger problem-solving skills in comparison with the group that did not undergo Performance assessment. Students tend to be more interested with activities and Mathematical tasks related to the real-world context, rather than learning about something



they perceived unnecessary and not applicable in real life. Through performance assessment task, learning experiences become realistic and enjoyable.

Scoring Rubrics

Performance task and scoring rubrics come together as one package. Typically, Performance task is evaluated using scoring rubrics. Since, Performance task does not yield with single correct answer or solution, it allows a wide range of responses, evaluation of students' products or performances is based upon judgment. Scoring Rubrics is a "generic scoring tool used to evaluate the quality of products and performances in a given outcome area" (Gabuyo, 2013). Also, rubrics display indicators of performance on the selected evaluative criteria across a range of level. Rubrics can either be holistic, provide an overall overview of the elements of product and levels of performance or analytic, provide a separate view of the different dimensions (Jonsson, 2014).

Brookhart (2013) defined rubric as a set of criteria that includes description of levels of performance quality that is used to assess any student performance. It is used by teachers identify what quality work is. It also aids students to judge their work and accept more responsibility for their own performance. It is also a great help for teachers to easily explain why the learners got the rate that they receive after a performance. Similarly, Isaacs, Zara, Herbert, Coombs and Smith (2013) defined rubric as a scoring guide containing the set of criteria that describes the outcomes the learners want to achieve. It is also viewed as a tool in assessing learners' performance. Thus, rubric is an assessment tool that clearly indicates the guideline to evaluate the quality of students' constructed responses.



Suskie (2009) listed ten advantages of using scoring rubrics in evaluating students' performance. These are the following: 1) It helps measure higher order thinking skills (HOT's); 2) It shows clear goals; 3) It explicitly represents the performance expectations; 4) It encourages self - improvement; 5) It inspires better performances from the students; 6) It gives feedback to the students; 7) It make scoring easier and faster; 8) It makes scoring consistent and unbiased; 9) It reduces questions from the students; 10) It improves feedback to faculty. Therefore, scoring rubrics shows what the range in the quality of the performance, what score should be given and what that score means.

Scoring rubrics are designed to be either analytical or holistic in their nature. Carrirevue (2010) defined analytic rubric presents a description of each level of achievement for each criterion and provides a separate score for each criterion. Meanwhile, he defined holistic rubric presents a description of each level of achievement but only an overall impression will be given to student performance task.

According to Clarke (2012) performance assessment tasks are reliable and valid through the use of scoring rubric. Moreover, the performance assessment can be used not only as a form of formative assessment but also a form of summative assessment. Hence, the researcher emphasized that the design of tasks and scoring rubrics should be aligned.

Traditional Method of Assessment versus Performance assessment

Assessment is an integral part of the teaching and learning process (Witte, 2012). Teachers can use a variety of assessment that can assess students' strengths and weaknesses to know if learning happens or not and to know what necessary steps that the teacher should take to make the teaching and learning process successful. The primary



goal of assessment is to enhance teaching and learning, not to sort or select students or justifies a grade (Borabo, 2014).

Traditional Method of assessment also known as “Standardized tests” has dominated the school in education for several decades (Brown & Abeywickrama, 2010). Traditionally, assessment tools in Mathematics mainly were mainly tests, quizzes and textbook exercises. But, as time goes by, standardized test cannot attain the goal of the teaching and learning process. This is because the world had changed. The economic trends and the trainings needed for new workforce require that the school system shift from a fact-oriented curriculum to one that emphasizes problem solving and innovation (William, 2011). NCTM (2016) stated that merely adding scores on written tests will not suffice to see if learning outcomes are attained or not.

Witte (2012) summarize several problems with traditional method of assessment. First, it penalizes creative thinking. Often, it leads to inert knowledge that is decontextualized to the extent that students’ knowledge has resembles a more repository of facts. Second, it is not a mirror of real-life problem situations. Third, it is susceptible to guessing and coaching and encourages the use of instructional method that resembles the tests. Fourth, it limits teaching to information and basic skills. Fifth, not theory based but based on the content of textbooks used at the time. Lastly, it does not develop Mathematical Competence.

On the other hand, McTighe (2015) list the benefits of using performance assessment. First, it involves authentic activities and values in their own right. Second, it models curriculum reform that identification and solutions of real-world problems, reasoning and Mathematical competence. Third, they contribute to instructional



improvement by focusing on instructional targets that are consistent with the goals of instructional activity. Fourth, they involve teachers in the development of the Mathematical performance task and scoring rubric. Lastly, lead to improve learning by engaging students in meaningful activities that are intrinsically motivating.

Performance assessments are authentic tasks that directly assess students' progress (William, 2015). They call for students to apply knowledge and skills rather than recall and memorize concepts and ideas, to reveal understanding. This assessment is not a single response, instead it allows students to explore, construct a response on their own, create their own product or demonstrate what they can do and understand (Earl & Timperley, 2014). Therefore, performance based assessment is well suited in assessing application of content –specific knowledge, integration of knowledge across subject areas and lifelong learning competencies that needed in real life such as communication, reasoning and proving, decision making, and problem solving (Collins, 2011).

Figure 1 shows the similarities and differences between traditional method of assessment and performance assessment.

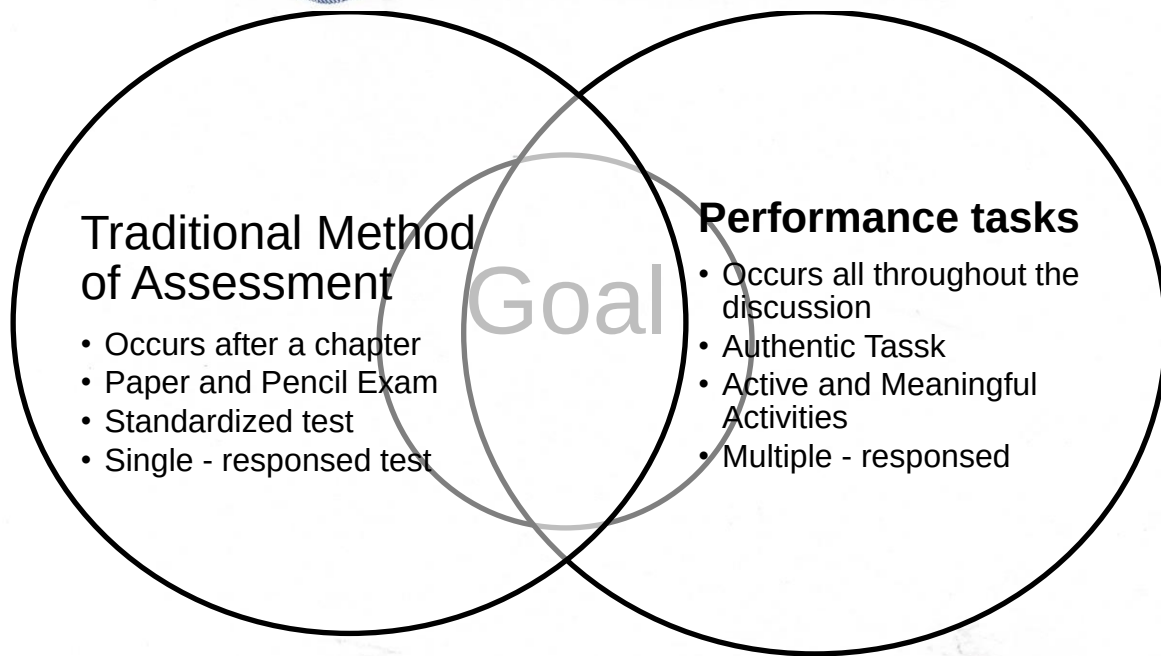


Figure 1. Similarities and differences between traditional method of assessment and performance assessment

Figure 1 shows that the major difference between implementing traditional method of assessment and performance assessment is that assessment happens only after a lesson or chapter while in performance-based assessment, assessment occurs throughout the teaching and learning process in the latter. Traditional method of assessment utilizes standardized tests such as multiple choices, identification, and fill in the blanks. This type of assessment is commonly known as “paper and pencil test”. On the contrary, performance assessment is a set of tasks that requires students to demonstrate their knowledge and skills by creating a response or a product (Yee & Bostic, 2014). Though, the two-assessment methods differed in approach, both have the same goal --- to assess students learning and Mathematical competence.

The shift from traditional method of assessment to performance assessment is a necessary step the teachers should do. William (2011) claimed that changing to



performance assessment which is more complex and meaningful will encourage instructional technique that promotes Math competences, and as a result, students' learning is improved. Performance based assessments are highly recommended because they better reflect good instructional practices, reflections of criterion performances, and are often more engaging for students. Semena and Santos (2012) defines validity as "an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness and actions based on test scores or other modes of assessment". Hence, performance assessment and scoring rubric come hand in hand to solve this existing weakness of performance assessment. Through scoring rubrics, assessment using performance assessment will be valid, reliable and unbiased.

Mathematical Modeling

Mathematics has always been viewed as a problem by the students of all ages ever since its introduction in the curriculum (Alkan, 2013). The greatest reason for this hatred in the Mathematics subject was stated by Rysdon (2010), and it is because students are still having a hard time finding the use of Mathematics in their lives. Furthermore, Barwell (2011) stated that students' definition of Mathematics is a complex and mechanical knowledge that is not needed in real life. Hence, Biembengut and Hein (2013) believed that through the use of Mathematical Modeling (MM) the students' perception with Mathematics will be changed and will treat it as a tool in solving real life problems and not just a mere body of complex ideas, techniques and procedures.

Mathematical Modeling has been an integral part of the society that plays a vital role in business, engineering and many other fields (Vos, 2013). With its importance, it just makes sense that it is now integrated in schools. Math Modelling is the process of choosing



and using appropriate Mathematics ideas and concepts to analyze and solve problems (NCTM, 2016). Wessels (2014) defines Mathematics modelling as a practice of making sense of the world through Mathematical perspective. Further, the Common Core State Standard Initiative of the United States of America (2018) added that Mathematics Modelling is the process of using various Mathematical structures-graphs, equations, diagrams, scatter plot, tree diagrams and so forth to represent real world situations.

Larson, Harel, Oerhtman, Zandieh, Rasmussen, and Speiser (2010) defined MM as the process of developing Mathematical descriptions, or models of real world. Furthermore, they stated that MM is not limited with expressing real-life problems in Mathematical language. It also involves associating phenomena in the situations in Mathematical language by using Mathematical concepts and representations. Furthermore, Lesh, et al. (2010) stated that MM tasks should not be used as isolated problem-solving activities. They should be used with model development sequences, where warm up and follow up activities are also important.

According to Arleback and Bergsten (2010) MM is regarded as the most significant goal of Math Education. It is useful because they help learners to develop, share and preserve their mathematical thoughts. It helps to portray, clarify or extend a mathematical idea by featuring its key ideas. Furthermore, it makes connections to relationships that exist between different Mathematical concepts. Also, it is a tool for Mathematics Learning because it gives meaning to Mathematics and serves as support in Mathematical understanding (GAIMME, 2016).

Similarly, Arsaven (2015) lists four reasons why MM is important for students. These are the following: 1) It helps students understand the world better; 2) It supports



Mathematical Learning; 3) It ensures developing various Mathematical qualifications and accurate attitudes; and 4) It provides sufficient support for the framework of Mathematics.

Likewise, Galbraith (2012) points two main uses of MM in teaching which were “modeling as a vehicle” and modeling as content. Modeling as a vehicle means providing an alternative setting in which students can learn Mathematics in a motivating way by introducing students to new Mathematics or to produce and refine their understanding of Mathematics they have learned. On the other hand, modeling as a content is experiencing modeling as content itself by enabling students to use their Mathematical knowledge and skills to solve real problems and to continue this ability overtime.

Also, Kang and Noh (2012) stated that MM is an innovative way of generating authentic learning and way of thinking. Furthermore, Arleback (2009) added that together with problem solving, communication and the history of Mathematical ideas, MM should be integrated in all Mathematics teaching. Lastly, in a study conducted by Wethall (2011) it showed that MM was related to student learning and attitude in Mathematics.

MM refers to the wide variety of ways to capture an abstract Mathematical concept or relationship (NCTM, 2016). It includes all the different ways the students depict on their Mathematical thinking as well as the processes they used to put their thinking into those forms. In addition, MM allow learners to experience the real-life application of Mathematics (NCTM, 2016). Through Math modeling learners learn how Mathematics is a necessity to solve real-world problems in many fields of the modern society (Vos, 2013).

Furthermore, in a study conducted by Wethall (2011) about the effects of MM to the academic performance and attitude of students in Mathematics results showed that there



is a significant relationship between the two variables. Moreover, it revealed that MM has a positive effect in the learning and attitude of the students. In addition, according to the results the students were more willing and able to solve new problems.

Similarly, in a study made by Unida (2011), where she developed an Instructional Materials with the integration of MM on selected topics in Mathematics, she found out that MM has a positive effect in the academic performance of the students. The developed Instructional materials were evaluated by experts and it was found out that Mathematical Modeling activities are good approach in teaching and learning Mathematics. Also, the Instructional materials were perceived as organized, useful and a good way to integrate MM that apply concepts in real – life problems.

In this study, the researcher wanted to integrate Mathematical Modeling in the teaching and learning process specifically in Performance assessment. Performance assessment is now having a crucial role in the teaching and learning process in the Philippines with the K to 12 system, where assessment is not only dependent on written works. The aforementioned studies showed that MM has a positive impact on the teaching and learning process. Furthermore, it helps to improve problem solving and critical thinking skills of the students which are the twin goals of the Mathematics curriculum.

Mathematical Model

A model is a tool that helps make sense of something (Wessels, 2014). Likewise, GAIMME (2010) defines model as concrete entities, pictures and objects in which some states of a concept desired to be developed are represented. Also, Papageorgiou (2009) describes a model as a tool to describe, interpret or construct behaviors or patterns.



Hesteness (2013) also added that a model is a set of related objects which may be real or imaginary, physical or mental, simple or composite. But, in Mathematics, a Mathematical model has a different meaning and used.

GAIMME (2015) defines Mathematical Model as an attempt to construct an analogy between an unfamiliar system and a previously known or familiar system. Accordingly, using Mathematical Model, people make sense and interpret real life situations. Further, Mathematical Model focuses on structural features and functional principles of objects or situations in real life. Also, Mathematical Model comprises a range of representations, operations, and relations, rather than just one, to help students develop higher order thinking skills in Mathematics beyond just computational and arithmetical skills, such as analyzing, spatial reasoning, predicting, interpretation and estimation.

According to Biembengut and Hein (2013) Mathematical model can be expressed using numerical expressions or formulas, diagrams, graphs, or geometric expressions, algebraic equations, tables, etc. Also, Cai, et al. (2013) stated that a Mathematical model is solely based on Mathematical objects that stimulate or represent selected features or behaviors of the thing without being the thing.

They added that Mathematical model has both epistemological and predictive value. Its epistemological value means that it is a way of knowing while its predictive value means experiment or knowing what is next. He also suggested that Mathematical Model can be compared to telescopes and microscopes, allowing students to see things that are hidden previously and a predictive tool allowing students to see what is next.



Moreover, Mathematical Models are very useful in different areas of life such as engineering, medicine, biochemistry and more. An example of good Mathematical model, that has a high level of predictive success which are still being used today are "Newton's Laws." and "Schrodinger's model of the subatomic world;" which is also known as "Quantum Mechanics" or the "Schrödinger Equation." This two Mathematical Models have become the way of knowing, understanding, describing, and talking about the subjects.

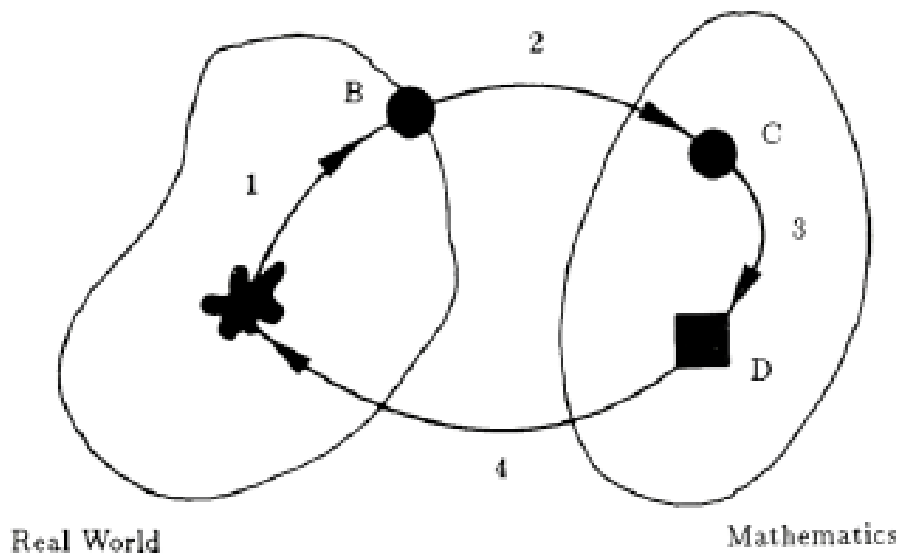
Lastly, in a study conducted by Arseven (2015) she found out that Models in Mathematics teaching are necessary to motivate the students, eliminate their anxiety and fear in the subject and allow them to develop a positive attitude in Mathematics. In addition, through the use of Mathematical Models students benefit by having meaningful learning, establishing relationship between Mathematics and real life. As stated by Pollak (2012), Mathematical Models represent real world situations with a Mathematical construct involving Mathematical concepts and tools.

Mathematical Modeling Cycle

Lingefjard (2006) defined Mathematical Modeling as a Mathematical process that involves observing a situation, conjecturing relationships, applying Mathematical analysis, obtaining Mathematical result, interpreting a model and applying it in real life. The Mathematical Modeling Process is being described as a cycle that is continuous. Though, there is no homogeneous Mathematical Modeling cycle there are several that are widely shared and accepted among researchers (Kaiser & Sriraman, 2006).

The first among those many accepted Modeling Cycle was developed by Blum (1988). As shown in Figure 2.

Figure 2. The Mathematical Modeling Cycle by Blum (1988)



- A) Real problem situation
- B) Real model
- C) Mathematical model
- D) Mathematical results

- 1, Specifying, idealizing, structuring
- 2, Mathematizing
- 3, Working mathematically
- 4, Interpreting, validating

This modeling cycle that was developed by Blum (1988) showed that Mathematics and reality are two separated entities (Shurmann, 2018). It also showed that real problem situations can be transferred in Mathematical world because they are interrelated and can have a real model that can be mathematized to become a Mathematical Model.

Another Mathematical Modeling cycle that was accepted by researchers is the one developed by the National Council of Teachers in Mathematics (NCTM, 1989) as shown in Figure 3.

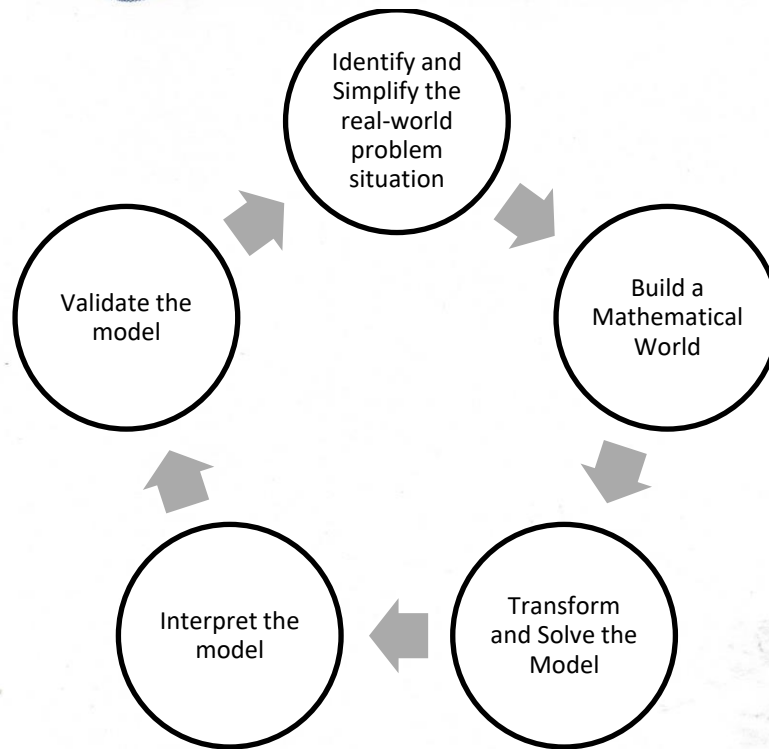


Figure 3. The Mathematical Modeling Cycle by NCTM (1989)

NCTM (1989) emphasized that Mathematical Model is a non-linear process that includes five interrelated steps. First, identify and simplify the real-world problem. Then, build a Mathematical world based on the problem. Afterwards, transform and solve the model from your Mathematical world. Later on, interpret what your model is for and lastly, validate the accuracy of your model. Such type of model can help teachers and students in experiencing Mathematical Modeling.

Another, Mathematical Modeling Cycle was developed by Blum and Leib (2006).

Figure 4 shows the developed Modeling Cycle.

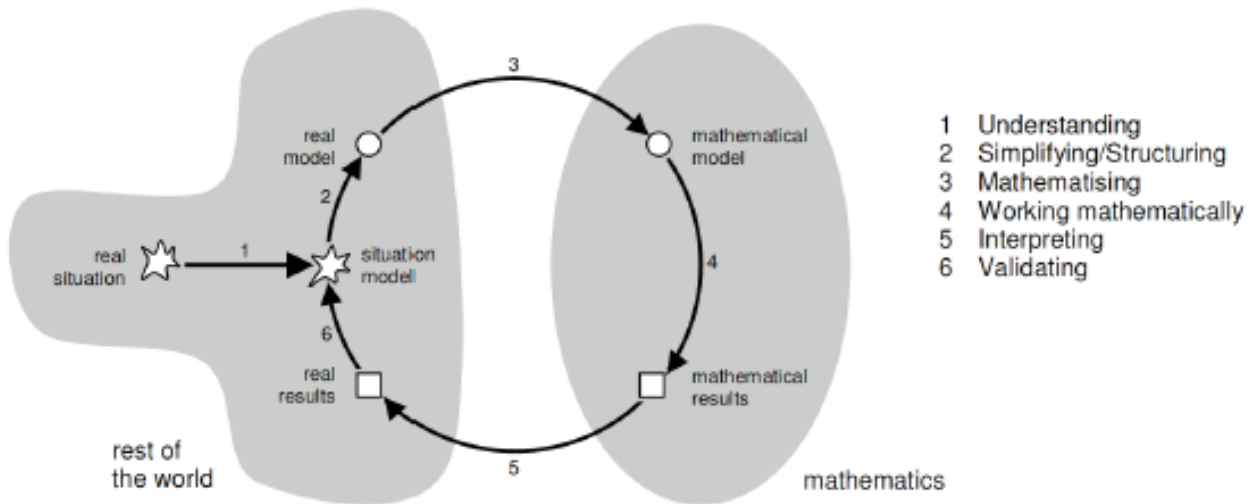


Figure 4. The Mathematical Modeling Cycle by Blum and Leib (2006)

This cycle is the most well known and most modified modeling cycle by different and several authors. This cycle involves the real world and Mathematical world as separate worlds that are connected through Mathematical Modeling. It involves understanding the problem in the real world, followed by simplifying or structuring. Then, Mathematizing, which shows the transferring of the ideas from the real world to the Mathematical world, followed by working Mathematically which indicates of solving the problem through Mathematics and lastly, interpreting and validating the model.

Furthermore, some examples where this model was modified are, Greefrath (2011) modified it by adding technology in the cycle and Saeki and Matsuzaki (2013) modified the cycle by inventing a dual modeling cyclic framework.

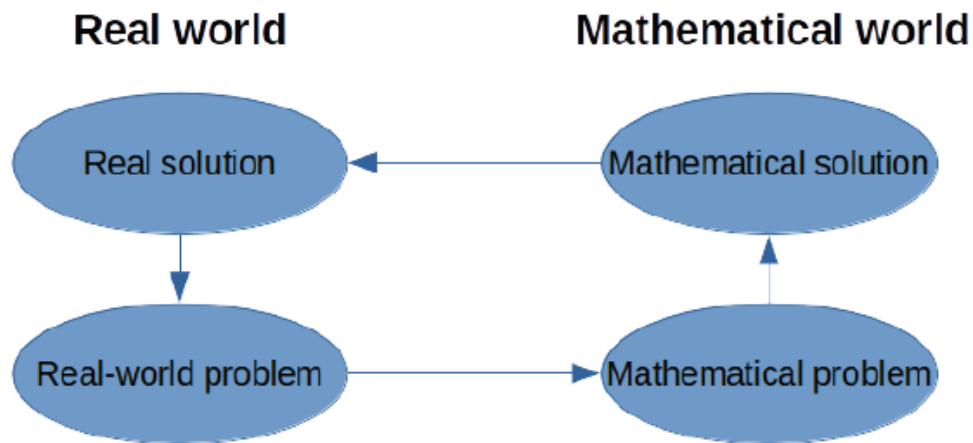


Also, the Programme for International Student Assessment (PISA, 2009) has their own developed Mathematical Modeling Cycle as shown in the Figure 5.

Figure 5. The Mathematical Modeling Cycle by PISA (2009)

In this modeling cycle, Mathematics and Real life are represented as two separate worlds. It showed that Mathematical Modeling must be considered as a process which organizes real world problems according to pre-established Mathematical Concepts.

In addition, Blum and Ferri (2009) has their developed Mathematical Modeling



Cycle as shown in Figure 6.

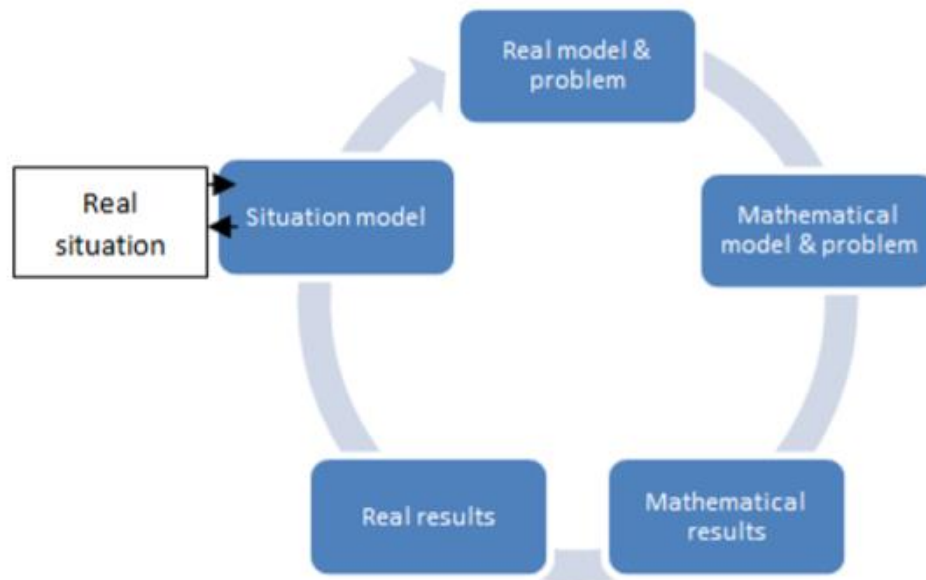


Figure 6. Mathematical Modeling Cycle by Blum and Ferri (2009)

This cycle involved seven steps namely: 1) Understanding the situation (problem); 2) Simplifying/Structuring; 3) Mathematizing; 4) Mathematical working; 5) Interpretation; 6) Verification; and 7) Presentation. Firstly, the problem situation should be understood by the student. After that, the situation is structured and turned into "a real model". The student should decide especially on what is worth doing at this point. During the mathematizing process, which corresponds to the third step, the student turns "the real model" into a "mathematical model". The student conducts "a mathematical work (calculation, solving inequalities etc.)" and reaches "the mathematical results" at the fourth step. Real results in the daily life are interpreted and verified during the fifth step. Finally, the possible solutions of the problem are presented and suggestions are made regarding the problem.

Another Mathematical Modeling Cycle existing is from Common Core State standards in Mathematics (CCSSM, 2010) as shown in Figure 7.

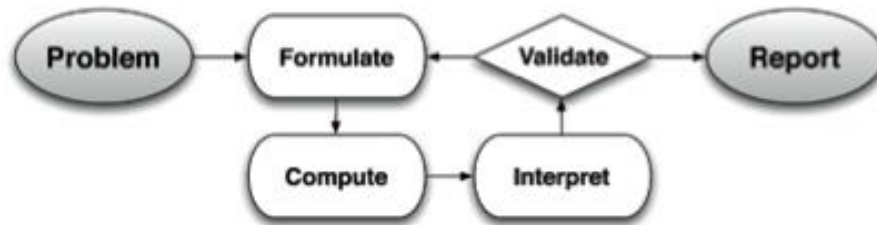


Figure 7. The Mathematical Modeling by CCSM (2010)

The modeling cycle presented in the Common Core State Standards for Mathematics begins with a real-world problem to be solved and ends with conclusions about the problem solved using Mathematics. The cycle includes identifying a problem that requires analysis to reach a solution by formulating a mathematical solution, or using model to draw conclusions. Thereafter, validate the accuracy of the answer and report or discussed the idea.

Lastly, GAIMME (2016) breaks the Mathematics Modeling cycle into six parts. Figure 8 shows the Mathematical Modeling Cycle by GAIMME

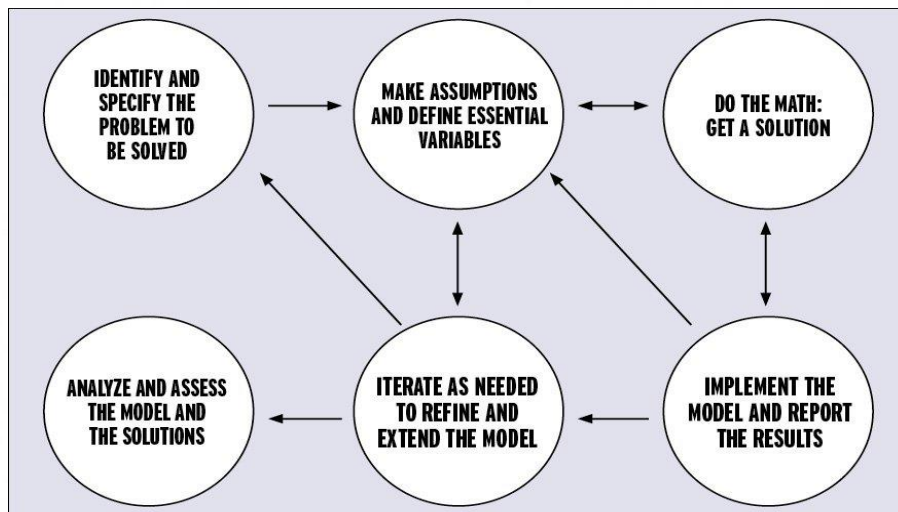


Figure 8. The Math Modeling Cycle by GAIMME (2016)



The Mathematics Modeling cycle involved: (1) identifying and specifying the problem to be solved; (2) formulating a model by making assumptions and defining essential variables; (3) analyzing and performing operations; (4) Interpreting and analyzing the results; (5) validating the conclusions and either improving the model or accepting it; and (6) Reporting the conclusions and reasons behind them.

Though, there are a lot of accepted Mathematical Modeling Cycle they all conveyed one idea. That is, real world can be transformed in Mathematical world and vice versa through Mathematizing. Mathematical Modeling enquires a translation between mathematics and the reality. Moreover, according to Pollak (1979), by the terms “the whole world outside the mathematics area” he means nature, society, daily life and other scientific discipline.

Integrating Mathematical Modeling inside the Classroom

Presently, Mathematical Modeling has been increasingly viewed as an educational approach to Mathematics education from elementary levels to higher education. In educational settings, mathematical modeling has been considered a way of improving students' ability to solve problems in real life (Shurmann, 2018).

Hence, the question on how to effectively integrate Mathematical Modeling inside the classroom is being asked. Though, in the present Mathematical Modeling inside the classroom is considered as a complicated process, there is no standard way of teaching Mathematics inside the classroom in relation to real – world through authentic activities (Erbas, et al., 2014).



Consequently, there are some known ways on how to integrate Mathematical Modeling inside the classroom. First are the three approaches in Mathematical Modeling inside the classroom by Galbraith (1989). These are: 1) General Application Approach; 2) Structure Modeling Approach; and 3) Open Modeling Approach.

General Modeling Approach focuses on a certain application in which the teacher introduces the model and the students use the model in a controlled manner. On the other hand, Structure Modeling approach uses the real-life situations and covers all the stages of the modeling process. Lastly, Open Modeling approach let the students do the work alone with limited help from the teacher.

While GAIMME (2016) used a framework on how to teach each Mathematical Modeling inside the classroom, table 1 shows the framework for teaching Mathematical Modeling.

Table 1

Framework for teaching Mathematical Modeling

Planning Checklist	The teacher needs to:
1. WHICH level of learning experience?	Decide which level (Level 1,2 or 3) of Mathematical Modeling learning experience that he/she wishes to focus on.
2. WHAT skills or competencies?	State the problem to be solved, if applicable, list all the specific skills and competencies (Mathematical or Modeling) that he/she targets in this learning experience.
3. WHERE is the Mathematics?	Write down the Mathematical concepts or formula or equations that will be needed in this learning experience.
4. HOW to solve the problem/model?	Prepare and provide plausible solutions to the problem identified in this learning experience.
5. WHY is this experience successful?	List factors or outcome that can explain why this experience is considered successful and look out for them during the activity.



Table 1 illustrates the framework for teaching Mathematical Modeling (MM) inside the classroom. The framework illustrates the W's and How's of creating a performance task on Math Modeling. First, the teacher needs to choose the level of the MM task. Blum and Leib (2006) categorized the MM task into three levels. Level 1 is learning basic Mathematical skills set in a real-life context, Level 2 is developing basic modeling competencies and Level 3 is undertaking a task that requires modeling skills and competencies. Modeling skills and competencies should be indicated, and topics should be specified. Lastly, provide a suitable approach and solution to the problem and plan for action if expected outcomes are not observed.

Development of Performance Tasks on Mathematical Modeling

Mathematics teaching is being done by stimulating Mathematical activities that show practical application of Mathematics in real life (Chan, 2009). The use of Mathematical Modeling task as a Performance task as showed in the study of Chan (2009) has not only enabled students to Mathematize but it also developed them as creative thinkers.

Oswalt (2012) define Mathematical Modeling tasks or also known as Model Eliciting Activities (MEAs) as a Mathematically – rich problem that engages students in Mathematical thinking, drawing upon their previously learned knowledge and supporting their understanding of the Mathematical concepts currently being covered.

Furthermore, Doerr and Lesh (2011) stated that through MEAs, students are challenged to intuitively realize Mathematical ideas and concepts embedded in a real-world problem and create relevant models in a relatively shorter amount of time. In



addition, Lesh, et al, (2010) added that MEAs should not be used as isolated problem-solving activities. They should be used within model development sequences where warm-up and follow-up activities are also important. Likewise, Oswalt (2012) suggested that MEAs should not have one definite answer. MEAs are not after the correct answer but the process the students come up with the answer. He also added MEAs should not be so narrow that students already know all of the Mathematics that will be needed to solve the problem. Lastly, any MEAs should enable students to provide varieties of answers based on their own interpretation of the problem.

Moreover, Galbraith (2006) lists six design principles in developing MEAs.

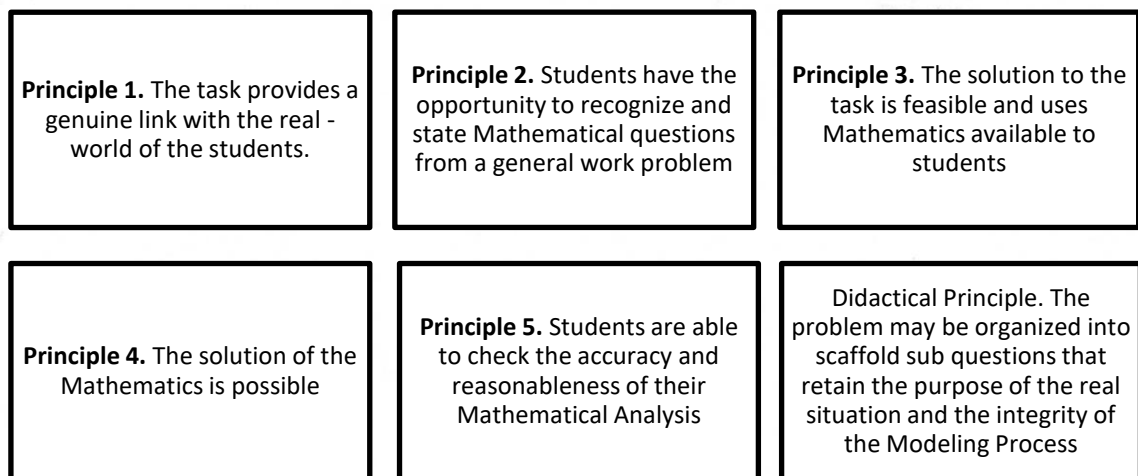


Figure 9. Six Design Principle of Galbraith

Figure 9 illustrates the six design principles of Galbraith (2006) that should be taken in consideration when creating performance task on MM. Galbraith (2006) design focuses on students' confidence in being able to accomplish the goals of the problem and mathematize real – world problems.



Also, the 6C's were also taken consideration in developing the performance tasks on Mathematical Modeling. These 6Cs are collaboration, critical thinking, creative thinking, communication, culture and connectivity. In schools, teachers are striving to educate their learners to achieve competence of thinking critically, conduct clear communication, have collaboration practices, respect culture, develop creativity and make good use of connectivity.

In addition, in a study by Unida (2011), she developed MEAs in selected topics in Mathematics. Results showed that the developed MEAs were good and can be used to easily learn Mathematical Concepts. The MEAs were perceived as organized, as a good reference material and a good way to apply Mathematical concepts in real life problems.

Statement of Purpose

The main purpose of this study was to develop and validate the performance tasks on Mathematical Modeling.

Specifically, this study aimed to achieve the following objectives.

1. Develop performance tasks on Mathematical Modeling.
2. Content validate the developed Performance task on Mathematical Modeling tasks developed in the study in terms of the following:
 - 2.1. Content Validity
 - 2.1.1. Established goals and standards/objectives;
 - 2.1.2. Learning Content, knowledge and skills; and
 - 2.1.3. Performance tasks on Mathematical Modeling standards.
 - 2.2. Usefulness
3. Try-out the validated Performance Task on Mathematical Modeling

Conceptual Framework

This study focused on the development of Performance task on Mathematical Modeling. Mathematical Modeling is a process in which real – life situations and relations in these situations are expressed by using Mathematics (Organization for Economic Co-operation and Development OECD, 2010). Subsequently, it is also a process that started with a problem situated in the Mathematical world transferring into real – world which then becomes a performance task. Figure 10 shows the conceptual framework of the study.

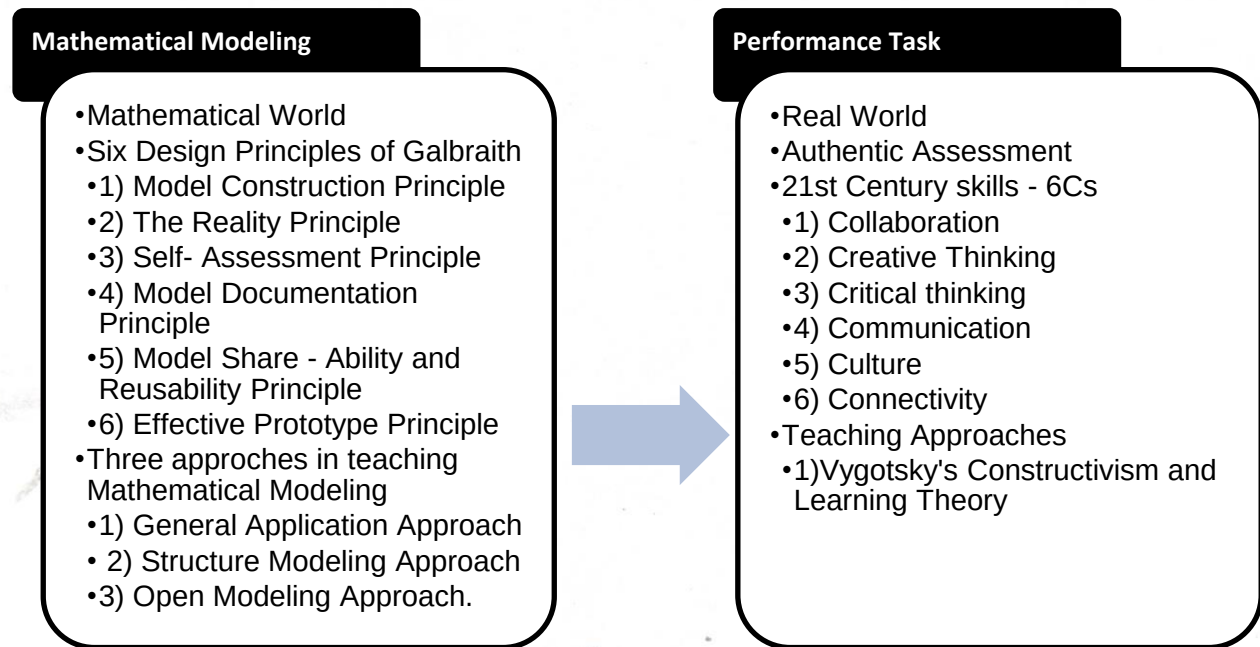


Figure 10. The Conceptual Framework

This study transforms Mathematical Modeling into a performance task. Mathematical Modeling task should have the six design principles by Galbraith (2006). Firstly, Principle 1 states that the tasks should provide a genuine link with the real-world situation. It means they are problems that are experienced by the students. Secondly, students must have the opportunity to recognize and state Mathematical questions. Thirdly, the solutions should be feasible and use Mathematics Concepts. Next is Principle 4, the problem should be possible to solve. Followed by the Principle 5 that states the students should be able to check the accuracy of their Mathematical analysis. And lastly,



the Mathematical modeling task should have sub questions that serve as the scaffold of learning. This six-design principle of Galbraith (2016) should be seen on the developed Mathematical Modeling.

Furthermore, in integrating Mathematical Modeling in the classroom the three approaches in teaching Mathematical Modeling should be used. These three are general modeling approach, structure modeling approach and open modeling approach. General Modeling Approach focuses on a certain application wherein the teacher introduces the model and the students use the model in a controlled manner. On the other hand, Structure Modeling approach uses the real-life situations and covers all the stages of the modeling process. Lastly, Open Modeling approach allows the students do the work alone with limited help from the teacher.

Also, this Mathematical Modeling task should have the characteristics of a performance task since they will be used as a performance task. Performance task is an authentic task that require students to perform a task or create a product connected to real life (Fullan, 2015). In K-12 system in the Philippines, performance task now takes a huge part in the teaching and learning process. Many of the skills that are emphasized nowadays are the so called "21st century skills" (Thijs, et al., 2014). Hence, it is advocated that this performance task should have the 21st century skills which are the 6Cs namely collaboration, creative thinking, critical thinking, communication, culture and connectivity. Miller (2015) defined this 21st century skills, he defined critical thinking as the way students filter, analyze and question any information, that they might receive. On the other hand, he defined creativity as the ability to innovate and explore new ideas for problem solving. He also defined collaboration as the way students work interdependently and



synergistically in teams with strong interpersonal and team related skills such as effective management of the team, making decisions together and learning from and contributing to the learning of others. Communication was defined by him as the mastery of three fluencies namely digital, writing and speaking tailored for a range of audiences. He defined culture as the ability to be in touch with everything that surrounds them and appreciate where they came from and their history. Lastly, he defined connectivity as encouraging students to connect with other people to build strong noble character.

Theoretical Framework

This study was anchored on the theory of constructivism and Learning Theory by Vygotsky. Constructivism discussed challenges the traditional goals of education and proposes restricted, innovative teaching approaches in which students will construct knowledge themselves rather than simply receiving it from knowledgeable teachers. It was significant to understand the theory of constructivism and how it was related to learning process due to its belief that people actively construct new knowledge as they interact with new environment (Vygotsky, 1986). Also, the Learning Theory of Vygotsky was underlying in the present study. For the purpose of curriculum to be developmentally appropriated, a teacher must plan activities that include not only what children were capable of doing on their own but what they can learn with the help of others. In this situation, teachers can use information about both levels of Vygotsky's zone of proximal development in organizing classroom activities via cooperative learning activities and scaffolding via a well-planned instruction. Therefore, these theories were relevant in the development of the performance task on MM and its pilot testing. It was taken consideration that MM tasks



should incorporate learning through experience, cooperative learning and scaffolding, otherwise they will not be considered MM tasks.

Significance of the Study

In general, the results of this study contributed to the growing awareness and understanding of the people concerned about Math Modeling. The study also benefits the following:

School Administrators. As they perform their main duties as instructional leader in the school, findings of the study can be utilized as input in designing their supervisory programs and activities. This could include the administrators to desire some scheme of strategies and support for the teachers and value them as human resource of the school catering a well improved assessment practice through innovation and technology application.

Parents. Heightening their awareness on the significant role they perform in educating their children, the continuous strengthening of the collaboration between the school and home will ascertain that the learner is provided the desired support which is an advantage in order to sustain his/her interest to undertake the different learning activities in Mathematics.

Students. The students are the direct beneficiaries of this study as they will find through the MM task that learning Mathematics is essential because Math is applicable in real life. The students themselves could understand the flow of achieving better learning in mathematics and in their subjects in general.



Mathematics teachers. The result of this study will serve as the basis of the mathematics teachers to be more enlightened in the concept of their teaching of Mathematics. This study will also influence the teachers in the manifestation of their assessment techniques for a more responsive and dynamic approach needed by the student in learning mathematics. Performance task on the introduced MM may serve as a utility towards academic achievement of the students.

Future Researchers. Other researchers in conceptualizing other studies can utilize the findings of this study. Variables not investigated maybe considered for future researches. Moreover, the literature in this study can be likewise be utilized in organizing the theoretical framework of other studies to be undertaken in future.

Definition of Terms

For clarity the terms used in the study were defined as follows:

Assessment. It is a process that produces evidences upon which subsequent feedback, decisions, predictions or placement are based (Witte, 2012). It is part of the education system of the k -12 in the Philippines that is consisted of three parts which are written works, performance task and quarter exam.

Authentic Assessment Task. It is a task that is closely aligned with activities that take place in real world settings and addresses real world problems (William, 2011). In this study, it refers to the performance tasks that replicate real-life situations.



Mathematical Model. It is a representation of a real-world situation in order to draw conclusions about the situation using Mathematical techniques (CCSSM, 2014). In this study, it refers to the equations formed to solve the given performance tasks.

Mathematical Modeling. It is a process in which real life situations and relations in these situations are expressed by using Mathematics, the transfer from Real world to Mathematical world through Mathematizing (GAIMME, 2015). In this study, it refers to formulating models to find solutions to problems.

Mathematical Modeling Cycle. It is a process of solving Math Modeling task through transforming real world into Mathematical world (CCSSM, 2010). In this study, it refers to transforming problems from classroom problems to real-life problems.

Performance Task. It is an authentic assessment designed to simulate or replicate important real-world challenges (William, 2011). In this study, it refers to the model eliciting tasks that replicate real life situations that was developed by the researcher.

Scoring Rubric. It is a scoring method used to judge the quality of performance of the students. It consists of criteria that specify both the knowledge and competencies for which the work must be evaluated (Gabuyo, 2013). In this study, it refers to the guidelines for assessment of students works.

Traditional Method of Assessment. It is a form of assessment that is relying solely on standardized test scores as the only criterion of teachers' effectiveness and students' progress in learning (Brown & Abeywickrama, 2010). In this study, it refers with the single response paper and pencil test.



Chapter 2

Methods

This chapter presents and discusses in detail the research design of the study, the population and sample of the study, the research instrument, the procedure that the researcher needed to take in developing and evaluation of the performance task on Mathematical Modeling (MM) and the potential ethical issues.

Research Design

This study was divided with three operational procedures namely; development of the performance task on MM, validation of the developed performance task by chosen experts that was divided in two phases and pilot testing of the validated performance task to the students by the subject teacher. This study utilized the design and development research approach to establish an empirical basis for the development of the performance task using MM.

This study utilized design and development research, also known as formative research and developmental research. Development in its simplest definition implies steady growth, improvement, evolution, and change. On the other hand, Court, et al. (2014) defines instructional development as the process of examining needs, determining what content must be mastered, creating educational objectives, designing materials/intervention to reach objectives and pilot-testing and revising the material/intervention in terms of learner achievement. Developmental research as defined by Plomp (2010) is a type of research that aims to improve the process of instructional design, development and evaluation through the production of knowledge. Similarly,



Sugiyono (2014) stated that developmental research is the process of transforming ideas into physical form. Thus, developmental research refers to the process of producing instructional materials, program and intervention that were described as accurate as possible and the final product was validated.

The primary goal of developmental research is to inform the decision - making process during the development of a product or program in order to improve the product or program being developed (Plomp & Nieveen, 2009). Therefore, formative evaluation is a very important part in the developmental research. The main purpose of formative evaluation in developmental research is to provide information that is needed in the cyclic learning process that will feed the loops of the design and development path. Furthermore, it is most useful when fully integrated in the process of analysis, design, evaluation, and revision. Moreover, in the process of improving the product or program, formative evaluation in development research should concentrate on locating errors and shortcomings in the product or program in its draft form and in generating suggestions and comments on how to improve the product or program. Hence, the basic contribution of formative evaluation in developmental research is quality improvement. Quality improvement in formative evaluation usually shifts from validity to practicality to effectiveness (Chyung, 2015).

Population and Sample of the Study

In this study, the researcher aimed to develop a performance task on MM. The researcher applied nonprobability sampling technique. In nonprobability sampling technique, the samples will be gathered in a manner that does not give all individuals in the population the equal chances of being selected (Michaels, 2015).



In the formative evaluation part of the study, the researcher used purposive sampling in selecting the pool of Math experts who validated the developed assessment tool. Purposive Sampling is a type of sampling in which, particular settings, persons, or events are deliberately selected for the important information they can provide that cannot be gotten as well from other choices (Albert, et al., 2010). The experts who validated the developed performance task in phase I were the five Math experts on Mathematical Modeling and Performance Tasks. In particular, two were from the Philippine Normal University (PNU) and both were Doctor of Philosophy and three were from DepEd – Division of Pampanga, one a Doctor of Philosophy and two were Masters of Education in Mathematics holders. On the second phase of the validation of the developed performance task after the initial try-out, three Math and Assessment experts from the Division of Pampanga validated the developed material.

On the other hand, the researcher applied convenience sampling technique in selecting the class in initial and final testing of the performance task. Etikan, et al. (2016) defined convenience sampling as a type of nonprobability sampling in which participants were sampled simply because they were convenient sources of data for the researcher. The class that was used for the initial testing of the developed performance tasks was the 25 Grade 10 students of San Esteban High School of the Academic Year 2018 – 2019 since they have already learned the Junior High School Algebra from Grade 7 to Grade 10. On the other hand, the 30 Grade 10 students of San Esteban High School of the Academic Year 2019 – 2020 were selected for the final testing of the developed material.



Research Instrument

The main instrument utilized in the formative evaluation and pilot testing of the study for the validation of the performance task was a validated feedback questionnaire that was developed by the researcher for the pool of experts.

In the construction of the questionnaires, the researcher read professional books, journals, published and unpublished theses related to her study. The researcher also collected items related to her study and used them in the questionnaire. The researcher was also guided by the specific problems of the study in the development of the instrument.

The first draft of the questionnaire was checked by the researcher's adviser and people who currently teach research subjects in the Graduate School. After the checking, suggestions were noted, and necessary corrections were incorporated in the initial draft.

The researcher subjected all the data gathering tools to the researcher's adviser's critiquing and evaluation. All necessary revisions of the instrument were considered before finalizing and using the instrument as tools for the data gathering part of the study.

Data Gathering Procedure

In order to develop and validate the Performance tasks on Mathematical Modeling, the researcher took the procedure below as shown in figure 12.

The procedure started by the researcher reading and examining books related to MM. The researcher also referred to and checked the objectives of the study which were the Algebra Competency Content of Junior High School that were included in the developed performance task on MM. The goal of the researcher was to create



performance tasks on Mathematical Modeling for Junior High School Algebra. Then, in the development of the Performance task on Mathematical Modeling, the researcher taken consideration the six principles by Galbraith (2006), the 6 C's, and the three approaches of MM. The six principles of Galbraith in developing model eliciting tasks were the following: (1) The tasks provide a genuine link with real-world of the students; (2) Students have the opportunity to recognize and state Mathematical questions from a general work problem; (3) The solutions to the task is feasible and uses Mathematics available to students; (4) The solutions of the Mathematics is possible; (5) Students are able to check the accuracy and reasonableness of their Mathematical Analysis; (6) The problem may be organized into scaffold sub questions that retain the purpose of the real situation and the integrity of the Modeling process. Galbraith (2006) designs focuses on the importance of mathematizing word problems instead of just providing one possible solution that may not applicable in real life. Furthermore, the integration of the 21st century skills which are the 6Cs namely collaboration, creative thinking, critical thinking, communication, culture and connectivity was done. Fuller (2014) defined these six 21st century skills for better understanding of their importance. He stated that collaboration engages students in team building wherein the students share their talents and skills to create a maximum outcome. He also defined creative thinking as an avenue of expressions that allow students to imagine, incorporate design, integrate function and use interdisciplinary approach. On the other hand, he defined critical thinking as problem solving, the ability to take information and put it to use to create solutions. Likewise, communication was defined by hm as a way the individual can share information. Then, he added that culture encourages students to appreciate their individuality and exchange respect. Lastly, he defined connectivity as a way that will let the students in touch with their world. Moreover, the three modeling



approaches were also used to integrate MM inside the classroom. The three approaches were general modeling approach, structure modeling approach and open modeling approach. The three approaches were used interchangeably, depending to the need of the tasks. General Modeling approach focuses on a certain application wherein the teacher introduces the model and the students use the model in a controlled manner. On the other hand, structure modeling approach uses the real-life situations and covers all the stages of the modeling process. Lastly, the open modeling approach allows the students the do the work with limited help from the teacher.

In order to gather evidence that will support the adequacy of established goals and standards/objectives; learning content, knowledge and skill; performance tasks on MM standards; and usefulness of the material to its intended users, experts' opinions were sought by the researcher. Hence, the first draft of the developed material was presented to the first batch of Math and performance tasks experts that involved two Philippine Normal University faculty member, two master teachers and one educational program supervisor. They examined the developed performance tasks based on two indicators which include: (1) Content Validity; and (2) usefulness of the developed material. In content validity, the experts will validate the developed material based from the established goals and standard/objectives, learning content, knowledge and skills, and performance tasks on Mathematical modeling standards. Then, the researcher revised the developed material based on the comments and suggestions of the experts. After the first phase of validation, the initial testing of the developed material was done to the 25 Grade 10 students of San Esteban High School from School Year 2018 – 2019. Later on, the second phase of the validation stage started with three Math and Performance task experts from the Division of Pampanga that includes areas that were not covered in the first phase of validation



which were the correctness of content and use of Mathematics and English language. Lastly, the final testing of the performance tasks on MM was done to the 30 Grade 10 Students of San Esteban High School from School Year 2019 – 2020. Finally, based from the experts' opinions and students' performance in the try-out, the performance tasks were revised and finalized.

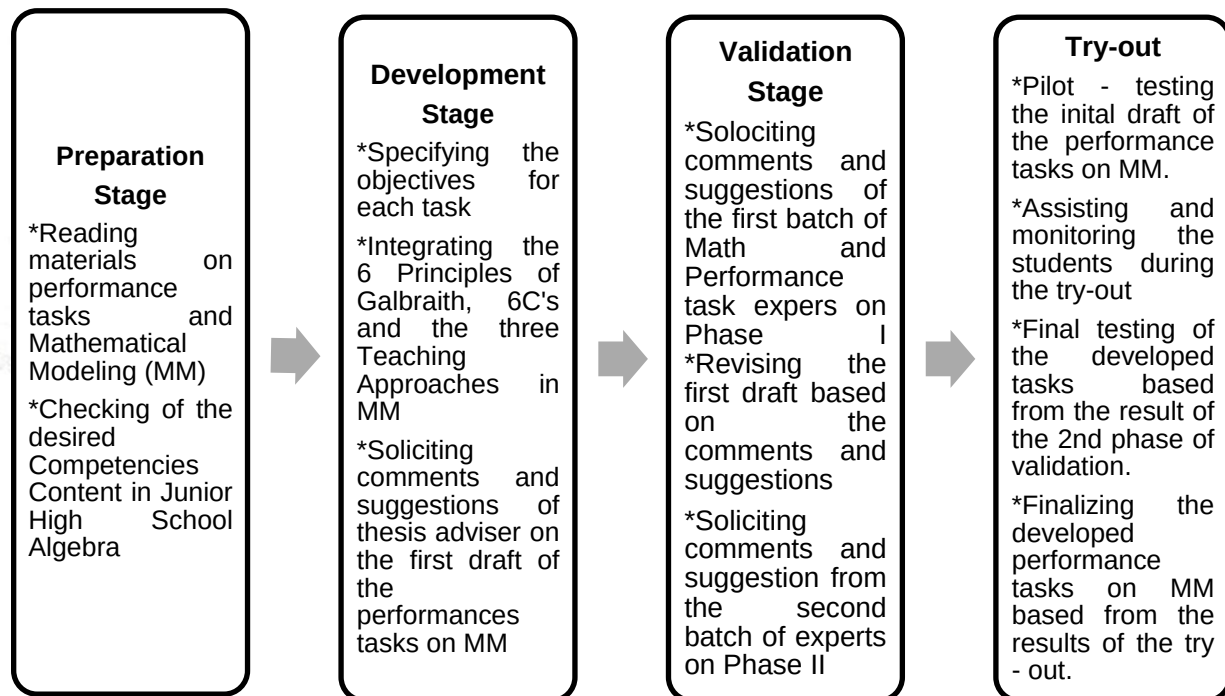


Figure 11. Process taken in developing and validating the performance tasks on Mathematical Modeling

To develop a Performance Tasks on Math Modeling the following procedures were followed:



Preparation Stage

The researcher read journals, articles, books and studies related to math modelling to construct performance task that developed learners' full potential and exhibited mathematizing word problems through Mathematical Modelling. Also, the researcher referred to the Mathematical competencies set by the Department of Education (DepEd) in Junior High School Algebra and the teaching approaches in Mathematical Modeling to developed a performance tasks using Mathematical Modeling.

Developmental Stage of the Performance Assessment task using Mathematical Modeling

The developmental Stage of the performance task on Mathematical modeling includes the following phases:

Phase I. Identified the exciting, interesting and meaningful Mathematical tasks that elicited Mathematical Modeling Tasks and were included in the performance task.

Phase II. Constructed the Math Modeling eliciting tasks that were included in the performance task based from the six principles of Galbraith and integration of the 6C's.

Phase III. Revised the first draft of the instructional material that contains technical and grammatical errors based on the thesis adviser's comments and suggestions.

Validation Stage

The validation stage of the performance task on Mathematical modeling includes the following phases:



Phase I: In the phase I of the validation, the pool of critics consists of five Math experts, two from Philippine Normal University and three from DepEd – Division of Pampanga were informed about the objectives of the study and were asked to validate the performance tasks on Math Modeling. The validity in terms of its content using the feedback questionnaire and validation sheets were assessed by the pool of experts. Suggestions were noted, and necessary corrections were incorporated in the final draft. Below were the comments and suggestions from experts and the corresponding actions taken by the researcher.

Table 2

Comments and Suggestions on the Developed Material from the First Batch of Experts and Actions taken by the Researcher

Experts	Comments and Suggestions from the experts	Action Taken by the Researcher
Expert 1 and 4	Improve the sentence construction of some statements.	Paraphrased and revised sentences to correct grammar and tenses added in the assessment tool.
Expert 2,3,4, and 5	Include another way of creating a model aside from excel.	Showed another technological tool in creating the model like GeoGebra in the teacher's guide.
Expert 1, 3, 4, and 5	Contextualize and localize the tasks	Change the tasks that were not observed and applied in the Philippines.
Expert 4	Use pictures that were not form the internet.	The researcher took pictures on her own to include in the tasks.
Expert 1,2,3, 4, and 5	Improve tasks that do not promote HOTS.	Revised and improve tasks to include HOTS.

Phase II. After the initial try-out of the developed performance task, the second phase of the validation process was started. Three Math and Performance Task experts



from the Division of Pampanga were selected to validate the developed performance task. The validity in terms of its content using the feedback questionnaire and validation sheets were assessed by the second group of pool of experts. Suggestions were noted, and necessary corrections were incorporated in the final draft. Below were the comments and suggestions from experts and the corresponding actions taken by the researcher.

Table 3

Comments and Suggestions on the Developed Material from the Second Batch of Experts and Actions taken by the Researcher

Experts	Comments and Suggestions from the experts	Action Taken by the Researcher
Expert 1, 2 and 3	Improve the correctness of content of the developed material.	Improve the tasks, based form the correctness of content.
Expert 2	Improve the use of Mathematical words	Improve vocabulary based from Mathematics language and context
Expert 1 and 2	Make tasks more relatable.	Change the tasks that were not observed and applied in the Philippines.

Try-out Stage

Before the try – out stage, the researcher sought permission from the Ethics Committee of Philippine Normal University and Schools Division Superintendent of the Division of Pampanga to pilot – test the developed performance task using Mathematical Modeling to get the students reaction through the feedback questionnaire administered after their exposure to the performance task. Upon approval of the request, the researcher



asked permission from the school head of San Esteban High School to conduct the study and personally administered and distributed the questionnaire to the student respondents. The performance task covered the Algebra lessons in Junior High School. Consequently, the 25 grade 10 students were divided into five groups to perform the tasks from Grade 7 to 10 JHS Algebra. Each had a chosen group leader to facilitate the groups.

The final testing of the validated performance task was administered to the 30 Grade 10 students of San Esteban High School. They were also divided into five groups to perform the revised tasks from the Grade 7 to 10 JHS Algebra with each group leaders to facilitate the tasks.

The Try-out of material involves the use of gathering of mean scores of the students on the tasks to help the researcher revise the material to make it more motivating and effective (Sadiman, 2016). This particular process was called the developmental testing. Developmental testing is an iterative process of test-modify-retest-modify cycles. The first component is the use of materials by a representative student and collection of data on his or her performance. The second component involves scoring the students performance to identify components of the instructional material which need modification. The third component is revising the material to improve its effectiveness. The final component in this cycle is retesting the revised material by the students. The cycle will only end when the material produced outstanding results (Kristano, et al., 2017).



Data Analysis

In analyzing the collected data, the following statistical treatment were used:

1. **Arithmetic Mean.** This refers to the average of a set of numerical values, computed by adding them together and dividing by the number of terms. It was used in determining the experts' validation on the developed performance task on Math Modeling.
2. **Standard Deviation.** This refers to the measure used to qualify the amount of variation or dispersion of a set of data values. It was also used to measure confidence in statistical conclusions.
3. **Rating Scale.** For the interpretation of the evaluation of performance task using MM from the pool of experts and students, the following rating was utilized.

3.51 – 4.00 Outstanding

2.51 – 3.50 Highly Satisfactory

1.51 – 2.50 Fair

1.00 – 1.50 Needs Improvement

Limitations of the Study

The developed performance tasks were validated through the chosen five Math experts from Philippine Normal University (PNU) and DepEd – Division of Pampanga for phase I and three Math and performance tasks experts from DepEd – Division of Pampanga for phase II of the validation stage. On the other hand, the pilot – testing of the developed performance task using Mathematical Modeling was done during the end of the



fourth quarter for the Academic Year 2018 – 2019 at San Esteban High School while the final testing of the developed material was done during the start of the third quarter for the Academic Year 2019 – 2020 at San Esteban High School. The study was limited in the validation of the performance task on MM to 25 Grade 10 students for the first trial and to 30 Grade 10 students for the final trial.

Ethical Consideration

Research ethics was taken in consideration in this study. In view of this ethical aspect and to avoid any foreseeable problem in the conduct of this study, permission to conduct such was secured from the school head, pool of Math experts and other concerned. Respondents were informed by the researcher about the purpose of the study and their contribution to it. Enough time was given to them in accomplishing the questionnaire and the unstructured interview. Consents from the respondents were secured for the usage of their given data. In addition, respondents were given the assurance that all the information that were gathered from them were treated with care and confidentiality and were only used for the purpose of the study. Furthermore, the results of the research were disseminated to the respondents.



Chapter III

Results and Discussions

This chapter deals with the presentation of the developed and validated Performance Tasks on Mathematical Modeling on Junior High School Algebra, collected data and its implications.

Objective 1: Developed Performance Tasks on Mathematical Modeling

The researcher developed and validated the performance tasks on MM on content area of junior high school Algebra. Specifically, there were two performance tasks for each grade level. Therefore, in total there were eight performance tasks on MM developed and validated.

The developed performance tasks on MM includes a preliminary teacher's guide that included the following parts: purpose, pre-requisite knowledge, materials needed, worksheet guide, objectives and learning competencies. This served as a guide to both the teacher and students to know what to expect in the task and what the students should learn after the task. The material also includes the Mathematical Modeling tasks that contains the integration of the six principles of Galbraith, 6Cs and three teaching approaches in MM. Moreover, series of questions were included that serves as the scaffold of learning. Lastly, the developed material also includes a "Teacher's guide – Possible solutions", that serves as a guide for the possible solutions of the students on the material. In order to assess students learning through their answers, the developed material included a standardized holistic rubric from NCTM that was developed by GAIMME (2015) as the guidelines for MM inside the classroom.



The researcher used the 6C's in developing the performance task using MM. Table 4 shows the matrix to determine which among of the 6C's the eight developed tasks had been integrated.

Table 4
6C's on the Performance Task on Mathematical Modeling

Tasks	Collaboration	Creative Thinking	Critical Thinking	Communication	Culture	Creativity
The Glass Slipper	/	/	/	/	/	/
Jeepneys	/	/	/	/	/	/
The Longest Jump	/	/	/	/	/	/
Aircon	/	/	/	/	/	/
Candle	/	/	/	/	/	/
Kick the Ball	/	/	/	/	/	/
Population of San Esteban	/	/	/	/	/	/
Savings Account	/	/	/	/	/	/

Table 4 shows which among the 6C's each performance tasks had. According to Galbraith (2016) a model eliciting task was collaborative, and elicit higher thinking order skills. Thus, integrating the 6C's in the development of performance tasks is not a difficult task. The eight developed performance tasks on MM all elicit the 6Cs as shown in the table above. Fullan and Langworthy (2014) defined this 21st century skills or 6Cs for better understanding to their used in the teaching and learning process. He stated that collaboration points to the way students use various personalities, talents and knowledge



to work together and produce something new. He also defined creative thinking as the ability of students to make use of their knowledge and talents to create something new or produce something in a new way. On the other hand, he defined critical thinking as problem solving, the ability to take information and put it to use to create solutions. Likewise, communication was defined by him as a way the individual can share information. Then, he added that culture encourages students to appreciate their individuality and exchange respect. Lastly, he defined connectivity as a way that will let the students in touch with their world.

The 21st century skills were incorporated to the performance tasks on MM by integrating the 6Cs in each performance tasks. Culture was fostered during the development of the performance tasks on MM by making the tasks contextualized and localized wherein the students can relate with the tasks given. In collaboration, student worked in small group with a leader who served as a facilitator. For connectivity, the students were encouraged to connect with their groups to build strong camaraderie and noble character. In communication, students presented their work in front of the class. Creativity was shown by developing a model to solve the problems. And lastly, critical thinking was integrated by critically evaluating the correctness of the model developed.

The researcher also utilized the three approaches in Mathematical opening namely: 1. General Application Approach; 2) Structure Modeling Approach; and 3) Open Modeling Approach. Table 5 shows which among the three approaches was used to integrate MM in the performance tasks.



Table 5

Three Approaches on the Performance Task on Mathematical Modeling

Tasks	General Application Approach	Structure Modeling Approach	Open Modeling Approach
The Glass Slipper		/	/
Jeepneys		/	/
The Longest Jump		/	/
Aircon	/		
Candle	/		/
Kick the Ball		/	/
Population of San Esteban	/		/
Savings Account	/		/

Consequently, the three approaches in Mathematical Modeling inside the classroom by Galbraith (1989) were integrated in the development of the performance tasks on MM. These are: 1) General Application Approach; 2) Structure Modeling Approach; and 3) Open Modeling Approach.

General Modeling Approach focuses on a certain application in which the teacher introduces the model and the students use the model in a controlled manner. On the other hand, Structure Modeling approach uses the real-life situations and covers all the stages of the modeling process. Lastly, Open Modeling approach let the students do the work alone with limited help from the teacher.

All the eight tasks utilized the open modeling approach as during the implementation of the tasks, the teacher serves only the facilitator of learning. The student did the tasks on their own with little help from the teacher. On the other hand, the tasks "The Glass slipper", "The Jeepneys", "The longest Jump" and "Kick the ball" applied the structured modeling approach. The students develop their own model to solve the problem.



On the contrary, “The Air Conditioner”, “The Candle”, “Population of San Esteban” and “Savings Account” applied the general modeling approach. The model for the problems were introduced and the students used it in controlled manner.

Objective 2: On Content Validity of the Performance Task on Mathematical Modeling tasks developed in the study.

Phase I of Content Validation of the Developed Materials.

The Phase I of the content validation of the developed performance task on MM includes five Math and performance tasks experts from Philippine Normal University and DepEd – Division of Pampanga. The experts validated the initial draft of the developed performance task on MM based from its established goals and standards/objectives; learning content, knowledge and skills; Mathematical modeling standards; and usefulness.

Content Validity tells if the assessment tasks relate to the appropriateness of the inferences, uses and consequences attached to the assessment (OECD, 2013). Similarly, Looney (2009) stated that validity is the most important single attribute an assessment tasks should possess because the validity of the assessment tasks is the extent to which it measures what it was designed to measure, without contamination from other characteristics. Table 6 shows the first phase of the experts’ validation on the content validity of the developed material in established goals and standard/objectives.



Table 6

Phase I: Experts Validation of the Developed Material in terms of Content Validity: Established Goals and Standard/Objectives

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. Objectives are clearly stated.	4	0	Outstanding
2. Objectives are specific, measurable and attainable.	4	0	Outstanding
3. Objectives are well-planned, formulated and organized.	4	0	Outstanding
4. Objectives are relevant to the set of competencies in the curriculum guide.	4	0	Outstanding
5. Objectives embrace important ideas that can be achieved through genuine application of knowledge and skills.	3.8	0.45	Outstanding
Grand Mean	3.96	0.09	Outstanding

The overall rating of the developed Performance Tasks using MM on its established goals and standards/objectives was Outstanding with a mean of 3.96 and standard deviation of 0.09. Established goals and standard/objectives as defined by William (2011) are the specific competencies that the students should acquire for each lesson. According to OECD (2013), an objective is needed to maximize the value of the assessment tasks because it helps the teachers and learners easily understand and interpret what is the intended action to be taken all throughout the assessment. Likewise, objectives and assessment are interrelated (Blanchett, et al., 2012). Objectives makes clear of the intended learning outcome and answers the question “what is it that students should be able to do at the end of the teaching – learning process?” (Allen, 2009). The result revealed that the developed tasks were able to follow the set of objectives and competencies of the JHS Algebra based on the curriculum guide developed by the DepEd. Moreover, the results indicated that the developed tasks considered the learning goals in accordance with the local standards.

In addition, experts believed that the established goals and standards/objectives embraced important ideas that can be achieved through genuine application of knowledge



and skills with a mean score of 3.8 which was interpreted as outstanding. They also agreed that the objectives were clearly stated, specific, measurable, attainable, well planned, formulated, organized and relevant to the set of competencies in the curriculum guide. All of these got the same mean average of 4 from the experts and interpreted as Outstanding with 0 standard deviation. Clearly defined objectives form the foundation for selecting appropriate content, learning activities and assessment measures (Hooves, 2012). When students clearly understand the learning objectives, students can see more easily the connections between what they are doing in class and they are supposed to learn (Pintrich, 2009). Hence, all the experts unanimously agreed that the developed material was accepted and outstanding in content validity in terms of the established goals and standard/objectives.

Table 7 shows the experts validation on content validity of the developed material in learning content, knowledge and skills in phase 1 of validation stage.

Table 7

*Phase I: Experts Validation of the Developed Material in terms of Content Validity:
Learning Content, knowledge and skills*

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. Contents are relevant to the defined objectives.	3.6	0.55	Outstanding
2. Contents are within the comprehension and interest of heterogeneous class.	3.4	0.55	Highly Satisfactory
3. Contents demand the use of different Mathematical Concept and Skills.	4	0	Outstanding
4. Contents enhance students Math Competence.	3.6	0.55	Outstanding
5. Contents encourage the use of different Mathematical Concept and skills.	3.6	0.55	Outstanding
Grand Mean	3.64	0.44	Outstanding

According to Posamentier, et al. (2010) the choice of Mathematical tasks by a Math teacher can have an impact on students' achievement in Mathematics. Mathematical tasks



can make or break a student depending on the worthiness and reliability of the Mathematical task. In addition, Mathematical tasks are used to develop the Mathematical competence and provide the kind of Mathematics the students need to experience. This is because tasks convey the true meaning of Mathematics and its real importance and application (Swan, 2009).

In the table shown above, it was revealed that the experts believed that the developed material contained tasks that were anchored with the learning contents, knowledge and skills needed in Mathematics with a mean average of 3.64 which was interpreted as Outstanding. A standard deviation of 0.44 shows that the degree of clustering of the validation from the mean in terms of learning content, knowledge and skills was not scattered. Hence, Mathematics tasks were designed to challenge students to intuitively realize mathematical ideas embedded in real life (Doerr & Lesh, 2011).

Furthermore, experts were convinced that the set of knowledge and skills of the developed performance tasks using MM demand the use of different Mathematical concepts and skills and higher order thinking skills (HOTS) with a mean score of 4. On the other hand, in terms of the relevance to the defined objectives, Mathematical competence, and use of different Mathematical skills and knowledge, experts agreed by a rating of Outstanding with an equivalent mean score of 3.6. Also, the set of learning contents, knowledge and skills were within the comprehension and interest of the heterogeneous class with an average mean of 3.4 with the Highly Satisfactory descriptive rating. Swan (2009) stated that the content of the Mathematical task should serve the following purpose: 1) develop fluency when recalling facts and performing skills; 2) interpret concepts and representation; 3) develop strategies for investigations and problem solving; 4) develop



awareness and values of Mathematics true meaning; and 5) appreciation of the power of Mathematics.

Table 8 shows the experts validation on content validity of the developed material in the performance tasks using Mathematical Modeling Standards in phase 1 of the validation stage.

Table 8

Phase I: Experts Validation of the Developed Material in terms of Content Validity: Performance Tasks on Mathematical Modeling Standards

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. It involves a complex, real world, and authentic application of the identified knowledge, skill and understanding.	4	0	Outstanding
2. It contains instruction that is clear to everyone.	3.6	0.49	Outstanding
3. It engages and challenges students to find answers.	3.8	0.4	Outstanding
4. It involves different concepts and ideas in Mathematics.	3.8	0.4	Outstanding
5. It provides a sense of accomplishments.	3.6	0.49	Outstanding
6. It promotes collaborative learning.	4	0	Outstanding
7. It involves creative and innovative application of concepts and skills.	4	0	Outstanding
8. It allows students to demonstrate understanding with some choices, options or variety in the performance and products.	4	0	Outstanding
9. It allows students to check, recheck and improve their work.	4	0	Outstanding
10. It allows students to use various ways of solving the problems.	4	0	Outstanding
Grand Mean	3.88	0.18	Outstanding

MM is the process of using Mathematical tools and methods to ask and answer questions about real – world situations (Abrams, 2012). With a mean of 3.88 and standard deviation of 0.18, it was revealed that the experts' validation of the developed material in terms of content validity: performance tasks using Mathematical Modeling was



Outstanding. Hence, the experts cohered that the developed material was anchored on the standards of performance assessment tasks and Mathematical Modeling.

In addition, the performance tasks contain the following characteristics of Mathematical Modeling namely: 1) It involves a complex, real world, and authentic application of the identified knowledge, skill and understanding; 2) It promotes collaborative learning; 3) It involves creative and innovative application of concepts and skills; 4) It allows students to demonstrate understanding with some choices, options or variety in the performance and products; 5) It allows students to check, recheck and improve their work; and 6) It allows students to use various ways of solving the problems. All of these got a mean average of 4 and a standard deviation of 0. Thus, all the experts unanimously agreed that the performance tasks achieved the goal to incorporate Mathematical modeling as a form of performance assessment. MM involves using Mathematics to better understand problems that arise in everyday life (CCSSM, 2010) Furthermore, OECD (2013) stated that MM links classroom Mathematics to everyday life, work and decision making. They also added that MM is the process of choosing and using appropriate Mathematics to analyze empirical solutions, to understand them better and to improve decisions. The experts were also convinced that the developed performance tasks engaged and challenged students to find answers and involved different concepts and ideas in Mathematics with an average mean of 3.8. Both got a rating of Outstanding with a mean equivalent of 3.6.

Therefore, experts approved that the developed Performance Tasks were able to attain the standard needed to be a model eliciting tasks. Likewise, the characteristics of a Mathematical Modeling tasks can be seen on the developed performance tasks. For this



reason, the developed material will be able to guide students to acquire true understanding of the lesson by making them experience true Mathematics by giving them issues and problems that needed different Mathematical knowledge and skills. Hence, MM supports the learning of useful skills and procedures, help develop logical thinking, problem solving and Mathematical habits of mind and promotes student discourse and reflective discussion (GAIMME, 2013).

Table 9 shows the summary of the experts' validation on the developed material in terms of content validity in the phase 1 of the validation stage

Table 9

Phase I: Summary Distribution of Experts Validation of the Developed Material in terms of Content Validity in Phase 1 of Validation Stage

Content Validity	Experts' Mean Distribution					Overall Mean
	1	2	3	4	5	
Established Goals and Standards/Objectives	4	4	4	3.8	4	3.96
Learning Content, Knowledge and skills	3.8	4	4	3.2	3.2	3.64
Performance Tasks Using Mathematical Modeling	3.9	4	4	3.9	3.6	3.88
Grand Mean	3.9	4	4	3.63	3.6	3.83

Interpretation: Outstanding

In general, the frequency distribution shows that the experts' validation of the developed material in terms of content validity was Outstanding with a mean of 3.83. The results showed that the experts approved the performance tasks using Mathematical Modeling in terms of its content validity which includes the established goals and objectives/standards; learning content, knowledge and skills; and performance tasks using Mathematical modeling standards. Content validity evidence allows us to make claims about what a test measure and make inferences about the students' knowledge and skills with respect to the construct (OECD, 2013). Further, content validity is intended to articulate the purpose of the assessment, understand and define the learning objectives,



and work to ensure alignment of the content to the intended purpose and objectives (Scott, 2010).

The developed performance tasks using Mathematical Modeling's usefulness got a grand mean of 4 and standard deviation of 0 which was interpreted as Outstanding. The result revealed that the developed material contained tasks that were able to develop the Mathematical knowledge and skill of the students. Furthermore, it also included contextual learning approach that provides applications of concepts, processes and principles, laws within the context of real – life situations.

Table 10 shows the experts validation of the developed material in terms of its usefulness in the phase I of the validation stage.

Table 10

Phase I: Experts Validation of the Developed Material in terms of its Usefulness

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. It motivates the students to learn Mathematics.	4	0	Outstanding
2. It is very useful in developing students' interest and curiosity.	4	0	Outstanding
3. It helps students develop critical thinking and problem solving.	4	0	Outstanding
4. It utilizes practical application and real – life situations that students can relate.	4	0	Outstanding
5. It allows the transfer of learning of concepts in real life.	4	0	Outstanding
Grand Mean	4	0	Outstanding

Usefulness refers to how learners, educators, school administrators and parents make sense of and respond to assessment result (OECD, 2013). The developed performance tasks using Mathematical Modeling's usefulness got a grand mean of 4 and standard deviation of 0 which was interpreted as Outstanding. The result revealed that the developed material contained tasks that were able to develop the Mathematical knowledge and skill of the students. Furthermore, it also included contextual learning approach that provides applications of concepts, processes and principles, laws within the context of real



– life situations. MM is considered as the bridge between the Mathematics learned and taught in schools and the Mathematics used in work place and society (Arleback, 2009).

Moreover, the developed material was useful because it motivates the students to learn Mathematics, useful in developing students' interest and curiosity, helps students develop critical thinking and problem solving, utilizes practical application and real – life situations that students can relate and allows the transfer of learning of concepts in real – life (OECD, 2013). All of which got an average mean of 4 and standard deviation of 0.

Table 11 shows the summary distribution of experts' validation on the developed material in the phase I of the validation stage. This includes content validity on established goals and standards/objectives; content, knowledge and skills; and performance tasks using MM standards and the developed material's usefulness.

Table 11

Phase I: Summary Distribution of Experts Validation on the Developed Material of the Validation Stage

Indicator	Experts' Mean Distribution					Overall Mean
	1	2	3	4	5	
1. Content Validity	3.9	4	4	3.63	3.6	3.83
1.1 Established Goals and Standards/Objectives	4	4	4	3.8	4	3.96
1.2 Learning Content, Knowledge and skills	3.8	4	4	3.2	3.2	3.64
1.3 Performance Tasks Using MM	3.9	4	4	3.9	3.6	3.88
2. Usefulness	4	4	4	4	4	4
Grand Mean	3.93	4	4	3.73	3.7	3.87
Interpretation: Outstanding						

The first phase of the experts' validation on the developed material recorded an overall mean of 3.87 which was Outstanding. Expert 1 got a total mean score of 3.93, experts 2 and 3 attained a total mean score of 4, expert 4 had a total mean score of 3.73 and expert 5 got a total mean average of 3.7 which showed that all experts believed that



the developed material was outstanding in terms of content validity and usefulness. This implied that the experts approved the use of the developed performance tasks using Mathematical Modeling to develop students' Mathematical knowledge and skills.

Phase II of Validation of the Performance Tasks on Mathematical Modeling

Content validity is an element of validity that is needed while assessing the classroom tasks. Furthermore, this type of validity requires the teacher to connect the test with the topics that they had already covered (Weigle, 2012). Similarly, Morrell and Carroll (2010) defined content validity as how well a test measures the content that was taught to the student. The second phase of the validation stage of the developed performance task on MM was done after the pilot-testing of the developed material that undergone the first phase of the validation stage. The second phase of the validation involves three Math and Performance Task experts of the DepEd-Division of Pampanga. The validation includes some indicators that were not mentioned in the first validation and was suggested by the first set of validators including correctness of content, use of Mathematical language with correct context and grammar.

Table 12 shows the second phase of the experts' validation on the content validity of the developed material in established goals and standard/objectives.



Table 12

*Phase II: Experts Validation of the Developed Material in terms of Content Validity:
Established Goals and Standard/Objectives*

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. Objectives are clearly stated.	4	0	Outstanding
2. Objectives are specific, measurable and attainable.	4	0	Outstanding
3. Objectives are well-planned, formulated and organized.	4	0	Outstanding
4. Objectives are relevant to the set of competencies in the curriculum guide.	4	0	Outstanding
5. Objectives embrace important ideas that can be achieved through genuine application of knowledge and skills.	4	0	Outstanding
Grand Mean	4	0	Outstanding

Results revealed that after the first phase of validation, the established goals and standard/objectives were enhanced through the comments and suggestion of the first batch of experts with a grand mean of 4 compared with the first validation with a grand mean of 3.96. All the indicators had a mean of 4 and standard deviation of 0, that showed that the final draft of the performance tasks on MM was outstanding. Gilbert (2009) state that learning objectives were what you expect participants to be able to do or talk about as a result to the learning experience. In detail, all validators agreed that the developed performance tasks on MM have objectives that were clearly stated, specific, measurable and attainable. Also, they agreed that the objectives were well planned, formulated, organized and relevant to the set of competencies in the curriculum guide. Likewise, the validators' responses showed that they agree that the objectives embrace important ideas that can be achieved through genuine application of knowledge and skills. Likewise, Blanchett, et al. (2012) stated that learning objectives focus on specific measurable and attainable learning outcomes and expectations, hence objectives should be clear, concise and measurable. Furthermore, Webb (2012) stated that well – written learning objectives can give students precise statements of what is expected of them and provide guidelines



for assessing students' progress. Lastly, a well-defined and made objectives can provide students with a clear purpose to focus their learning efforts, plan and improve instruction, facilitate evaluation, guide assessment strategies and produce new insights (OECD, 2013).

Table 13 shows the experts validation on content validity of the developed material in learning content, knowledge and skills in phase II of validation stage.

Table 13

Phase II: Experts Validation of the Developed Material in terms of Content Validity: Learning Content, knowledge and skills

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. Contents are relevant to the defined objectives.	4	0	Outstanding
2. Contents are within the comprehension and interest of heterogeneous class.	4	0	Outstanding
3. Contents are Mathematically correct and accurate	3.67	0.47	Outstanding
4. Contents are grammatically correct.	4	0	Outstanding
5. Contents demand the use of different Mathematical Concept and Skills.	4	0	Outstanding
6. Contents enhance students Math Competence.	3.67	0.47	Outstanding
7. Contents encourage the use of different Mathematical Concept and skills.	4	0	Outstanding
Grand Mean	3.91	0.13	Outstanding

Compared with the first phase of validation with a grand mean of 3.64 and standard deviation of 0.44, the second phase of validation was with a mean of 3.91 and standard deviation of 0.13, it was revealed that the contents of the final draft of the developed performance tasks on MM was more outstanding compared to the initial draft. Two indicators were added on the survey questionnaire for learning content, knowledge and skills as suggested by the first batch of experts who validated the developed material on the phase I of the validation stage. These were "Contents are Mathematically correct and accurate" and "Contents are grammatically correct".



Table 14 shows the experts validation on content validity of the developed material in the performance tasks using Mathematical Modeling Standards in phase II of the validation stage.

Table 14

Phase II: Experts Validation of the Developed Material in terms of Content Validity: Performance Tasks on Mathematical Modeling Standards

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. It involves a complex, real world, and authentic application of the identified knowledge, skill and understanding.	4	0	Outstanding
2. It contains instruction that is clear to everyone.	4	0	Outstanding
3. It engages and challenges students to find answers.	3.67	0.47	Outstanding
4. It involves different concepts and ideas in Mathematics.	3.67	0.47	Outstanding
5. It provides a sense of accomplishments.	4	0	Outstanding
6. It promotes collaborative learning.	4	0	Outstanding
7. It involves creative and innovative application of concepts and skills.	4	0	Outstanding
8. It allows students to demonstrate understanding with some choices, options or variety in the performance and products.	4	0	Outstanding
9. It allows students to check, recheck and improve their work.	4	0	Outstanding
10. It allows students to use various ways of solving the problems.	4	0	Outstanding
Grand Mean	3.93	0.09	Outstanding

Table shown above revealed that the final draft of the developed material was outstanding with a mean of 3.93 and standard deviation of 0.09 on Performance Tasks on MM Standards. Mathematical Modeling is the process of using Mathematical tools and methods to ask and answer questions about real – world situations (Abrams, 2012). In addition, the indicator “It involves a complex, real world, and authentic application of the identified knowledge, skill and understanding” had a mean of 4 and standard deviation of 0. Hence, Mathematical modeling involves using Mathematics to better understand



problems that arise in everyday life (CCSSM, 2010). Also, the indicators “It involves creative and innovative application of concepts and skills”; “It allows students to demonstrate understanding with some choices, options or variety in the performance and product.”; “It allows students to check, recheck and improve their work.”; and “It allows students to use various ways of solving the problems.”, all got a mean of 4 and standard deviation of 0. Thus, MM supports the learning of useful skills and procedures, help develop logical thinking, problem solving and Mathematical habits of the mind and promotes student discourse and reflective discussion (GAIMME, 2012).

Therefore, the final draft of the developed material was a better version compared to the initial draft with a mean of only 3.88 and standard deviation of 0.18. Nevertheless, both the initial and final draft of the developed material were outstanding by nature by the validation of the first and second batch of experts in the validation stage. Furthermore, MM is at the very heart of Mathematics, showing its importance and relevance as a human activity, thus providing motivation for the study of Mathematics (Galbraith, 2012).

Table 15 shows the summary of the experts’ validation on the developed material in terms of content validity in the phase II of the validation stage

Table 15

Phase II: Summary Distribution of Experts Validation of the Developed Material in terms of Content Validity in Phase 1 of Validation Stage

Content Validity	Experts’ Mean Distribution			Overall Mean
	1	2	3	
Established Goals and Standards/Objectives	4	4	4	4
Learning Content, Knowledge and skills	3.62	3.7	3.7	3.67
Performance Tasks Using Mathematical Modeling	3.9	3.9	4	3.93
Grand Mean	3.84	3.87	3.9	3.87
Interpretation: Outstanding				



Validity refers to the evidence needed to support the way test scores are used and the impact these uses can have on individuals (Gilbert, 2012). In general, the frequency distribution on the second phase of validation shows that the experts' validation of the developed material in terms of content validity was Outstanding with a mean of 3.87. Content validity as defined by Pintrich (2009) refers to the actual content within the assessment tasks. The results showed that the experts approved the performance tasks using Mathematical Modeling in terms of its content validity which includes the established goals and objectives/standards; learning content, knowledge and skills; and performance tasks using Mathematical modeling standards. Furthermore, there is only 0.04 difference between the first phase and the second phase of validation on content validity of the developed material with a general mean of 3.83 and 3.87 respectively.

Table 16 shows the experts validation of the developed material in terms of its usefulness in the phase II of the validation stage.

Table 16

Phase II: Experts Validation of the Developed Material in terms of its Usefulness

Indicator	Mean	Standard Deviation	Verbal Interpretation
1. It motivates the students to learn Mathematics.	4	0	Outstanding
2. It is very useful in developing students' interest and curiosity.	4	0	Outstanding
3. It helps students develop critical thinking and problem solving.	4	0	Outstanding
4. It utilizes practical application and real – life situations that students can relate.	4	0	Outstanding
5. It allows the transfer of learning of concepts in real life.	4	0	Outstanding
Grand Mean	4	0	Outstanding



Both on the first and second phase of validation of the developed material, the grand mean is 4 and standard deviation is 0. Hence, both the first and the second batch of experts found the developed material useful to both the teachers and students to develop their Mathematical ability.

Table 17 shows the summary distribution of experts' validation on the developed material in the phase II of the validation stage. This includes content validity on established goals and standards/objectives; content, knowledge and skills; and performance tasks using MM standards and the developed material's usefulness.

Table 17
Phase II: Summary Distribution of Experts Validation on the Developed Material

Indicator	Experts' Mean Distribution			Overall Mean
	1	2	3	
1. Content Validity	3.84	3.87	3.9	3.87
1.1 Established Goals and Standards/Objectives	4	4	4	4
1.2 Learning Content, Knowledge and skills	3.62	3.7	3.7	3.67
1.3 Performance Tasks Using Mathematical Modeling	3.9	3.9	4	3.93
2. Usefulness	4	4	4	4
Grand Mean	3.88	3.94	3.95	3.92
Interpretation: Outstanding				

In the second phase of validation, the developed material recorded a grand mean of 3.92 from the three experts on the content validity and usefulness of the materials. Expert 1, 2 and 3 recorded a grand mean of 3.88, 3.94 and 3.95 respectively. In sum, the validators strongly agreed that the two aspects of the developed performance tasks on MM (Content validity and usefulness) can be described outstanding based for the validation of the three Math and performance task experts. In general, the developed material provides established goals and objectives/standards that were clearly stated,



specific, measurable, attainable, well-planned, formulated, organized, relevant to the competencies in the curriculum guide and embrace important ideas that can be achieved through genuine application of knowledge and skills. Likewise, the learning content, knowledge and skills were relevant to the defined objectives, within the comprehension and interest of heterogeneous class, demand the use of different Mathematical concept and skills, enhanced students Math competence, and encourage the use of different Mathematical concept and skill. Furthermore, the contents were accurate and correct and also use correct Mathematical and English words. Also, the performance tasks on MM standards were applied correctly and properly. These involved the application of Mathematical knowledge and skills in real-life situations, requiring collaboration, creative thinking, critical thinking, culture, communication and connectivity in the developed tasks. Thus, MM tasks were specifically designed to challenge students to use Mathematical knowledge and skills to solve real – world problems and to create relevant models in relatively short period of time (Lesh & Doerr, 2011). Furthermore, in the implementation of the MM tasks students worked in small groups and expected to work together on creating shareable and reusable models (English, 2009). Lastly, the developed material can be used as a tool in enhancing the Mathematics skills and knowledge of the students. Thus, the development of the material was both timely and appropriate as was shown by the responds of the validators with a mean of 4 and standard deviation of 0 by all the validators.

Objective 3. Try-out the developed performance tasks on MM.

The pilot-testing of the performance tasks on MM was done to the Grade 10 students of SY 2018 – 2020 while the final testing of the material was done to the Grade 10 students of SY 2019 – 2020. The students were divided into five groups, with a leader



that serves as a facilitator. The students were able to developed their own model using the excel and GeoGebra. On the other hand, their works were assessed by the teacher through the standardized survey questionnaire by GAIMME (2015).

Table 18 shows the mean scores of the groups on the pilot testing of the eight developed performance tasks using the standardized survey questionnaire by GAIMME (2015).

Table 18

Mean Scores of the Groups on the Pilot Testing of the eight performance tasks on MM using the Standardized Rubric for MM of GAIMME (2015)

Indicator	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Grand Mean
Define the Modeling Problem	3.4	3.4	3.2	3.2	3.4	3.2	3.60	4.00	3.43
Building the Model: Make assumptions and acknowledge limitations	2.8	3.2	3	2.4	3	3	3.80	4.00	3.15
Building the Model: Define variable and identify parameters	3.2	3.6	3.6	3	3.4	3.2	3.40	3.60	3.38
Solution: Models uses meaningful Mathematics	3	3.2	3	2.4	3.2	2.8	3.40	3.60	3.08
Solution: Results are accessible to the audience	3	3.4	3.6	3	3.2	3	3.40	3.60	3.28
Analysis and Assessment of Model	3.2	3	3	3	3.4	3	3.40	3.60	3.20
Writing Style and Organization	3	3	3	3	3.6	3	3.60	3.80	3.25
Mean Interpretation	3.09	3.26	3	2.9	3.31	3.03	3.51	3.74	3.23

Highly Satisfactory

Table 18 shows the scores of the Grade 10 students on the pilot testing of the performance tasks on MM. Pilot testing is one of the essential stages in a development and design research and is conducted to identify the potential problem areas and



deficiencies in the developed material (Swan & Burkhardt, 2012). Furthermore, pilot testing was done to assess the efficacy, feasibility and doability of the developed material (Saks & Burke, 2012). Results revealed that overall, the Grade 10 students scored highly satisfactory on the developed performance tasks on MM with a mean of 3.23. Thus, the developed tasks were feasible, doable and efficient in nature. In detail, task 8 entitled “The Savings Account” scored the highest mean with 3.74, while task 4 entitled “The Airconditioner” scored the lowest with a mean of 3.23.

Table 19 shows the mean scores of the second batch of respondents on the final testing of the eight developed performance tasks using the standardized survey questionnaire by GAIMME (2015) after the second validation.

Table 19
Mean Scores of the Groups on the Final Testing of the eight performance tasks on MM using the Standardized Rubric for MM of GAIMME (2015)

Indicator	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Grand Mean
Define the Problem	3.4	3.6	3.2	3.2	4	3.2	4	4	3.58
Building the Model: Make assumptions and acknowledge limitations	3	3.6	3	3.8	3.2	3	4	4	3.45
Building the Model: Define variable and identify parameters	3.2	3.6	3.6	3	3.4	3.2	4	4	3.50
Solution: Models uses meaningful Mathematics	3.2	3.6	3	3	3.2	3.8	3.8	3.8	3.43
Solution: Results are accessible to the audience	3.2	3.4	3.6	3	3.2	3.6	3.8	3.8	3.45
Analysis and Assessment of Model	3.8	4	3.6	3.2	3.8	3.8	3.6	4	3.73
Writing Style and Organization	3.6	3.2	3.2	3.8	3.6	3.6	4	4	3.63
Mean	3.34	3.57	3.31	3.29	3.49	3.46	3.89	3.74	3.51
Interpretation	Outstanding								



Table 19 shows the scores of the second batch of Grade 10 students on the final testing of the performance tasks on MM. It revealed that overall, the Grade 10 students scored outstanding on the revised performance tasks on MM after the second evaluation with a mean of 3.51. In addition, task 7 entitled “The Population at Barangay San Esteban” scored the highest mean with 3.89, while task 4 entitled “The Airconditioner” scored the lowest with a mean of 3.29. The second validation and testing was done to improved the developed material until it reach a level of theoretical termination point; when the material produce outstanding results (Arikunto, 2015). Hence, the material did not need any more modification and can be used by the teachers as a performance assessment to the students.



Chapter IV

Summary, Conclusions and Recommendations

This chapter presents the summary of the study, summary of the results, conclusions and recommendations of the study.

Summary of the Study

Mathematics teaching should be done by stimulating Mathematical activities that show practical application of Mathematics in real life. The use of Mathematical Modeling task as a Performance task enabled students to Mathematize word problems and it also developed learners as creative thinkers (Chan, 2009). Hence, the researcher developed performance tasks on MM as per DepEd order no. 8 s. 2015, wherein performance tasks became part of the assessment of the students.

The researcher followed a revised Instructional Design Model (IDM) for the systematic production of instruction that includes the development and validation of the performance tasks on MM. Phase I involves reading of journals, articles, books and studies related to math modelling to construct performance task that will develop learners' full potential and will exhibit mathematizing word problems through Mathematical Modeling (MM). Also, the researcher referred to the Mathematical competencies set by the Department of Education (DepEd) in Junior High School Algebra and the teaching approaches in Mathematical Modeling to developed a performance tasks on Mathematical Modeling. In the developmental stage, the researcher identified exciting, interesting and meaningful tasks for the students and constructed the Mathematical Modeling eliciting tasks included in the performance task based on the Six Principles of Galbraith and 6Cs.



In the validation stage, two phases were included. In phase I, pool of critics consists of five Math experts from Philippine Normal University and the Department of Education (DepEd) Division of Pampanga, were asked to assess the performance tasks on MM. In the second phase, three Math experts from the Department of Education (DepEd) Division of Pampanga. The validity in terms of its validity content and usefulness through the use of the feedback questionnaire and validation sheets were assessed by the pool of experts. Lastly, in the try – out stage, pilot testing of the performance tasks on MM was conducted to the Grade 10 students of San Esteban High School, School Year 2018 – 2019 while the final try – out was conducted to the Grade 10 students of San Esteban High School, School Year 2019 – 2020. The performance task covered the Algebra topic of Junior High School Mathematics.

Summary of Results

Using the procedures described in Chapter 2, the objectives of the study were attained and can be summarized.

1. There were eight developed performance tasks on MM on content area of Junior High School Algebra. Also, the developed performance tasks on MM catered the six principles of Galbraith, the 6Cs and the three approaches of MM.
2. In general, the developed performance tasks on Mathematical Modeling were able to achieve the desired content validity such as to established goals and objectives/standards, learning content, knowledge and skills and performance tasks using Mathematical Modeling standards. Likewise, the developed performance tasks on Mathematical Modeling is useful because it motivates learners to learn Mathematics by incorporating practical application of Mathematical knowledge and



skills in real-life situations that students can relate. Similarly, it was useful in developing students' interest, curiosity, critical thinking and problem solving. Lastly, it allows the transfer of learning of concepts into real-life situations.

3. The students were able to do the performance tasks with minimal help from the teachers. Further, the students used GeoGebra and excel to find the appropriate model for each task and checked the error of the model they used.

Conclusions

Based on the key results of this study, the following conclusion were drawn.

1. Mathematical Modeling Tasks can be used as a form of assessment particularly as a form performance task, since it uses Mathematical knowledge into real world problems.
2. Mathematical Modeling Tasks are valid if it involves a complex, real world, and authentic application of the identified knowledge, skill and understanding. It is also valid if it promotes collaborative learning, critical thinking, creative and innovative application of concepts and skills.
3. Mathematical Modeling Tasks are tasks that transforms the real world into Mathematical world. By doing so, students appreciate the need to learn Mathematics and its application into real world.



Recommendations

Based on the foregoing findings and conclusions, this study forwards the following recommendations.

1. Teachers are encouraged to fully utilize the developed material to establish the acquisition of true understanding among the students and to reinforce the teaching and learning process in Mathematics. The developed performance tasks on MM can be used as the assessment for the 40% of the academic achievement of the students allotted in the performance tasks as arranged by the DepEd order no. 7 series of 2015.
2. Teachers are encouraged to create learning activities and performance tasks that are anchored with the established goals and learning content set by DepEd and promotes the use of Mathematical Modeling Standards.
3. Further studies on the evaluation of the developed material should be conducted to determine the effect of the material on the academic achievement of the students.
4. Future researchers are advised to refine the developed performance tasks using Mathematical Modeling and discover its effect in the academic performance of the students in Mathematics.
5. Further studies on the effect of Mathematical Modeling in the academic performance of the students.



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APPENDIX A

THE DEVELOPED PERFORMANCE TASKS ON MATHEMATICAL MODELING



Performance Tasks on Mathematical Modeling

Vanessa P. Pangan

WRITER



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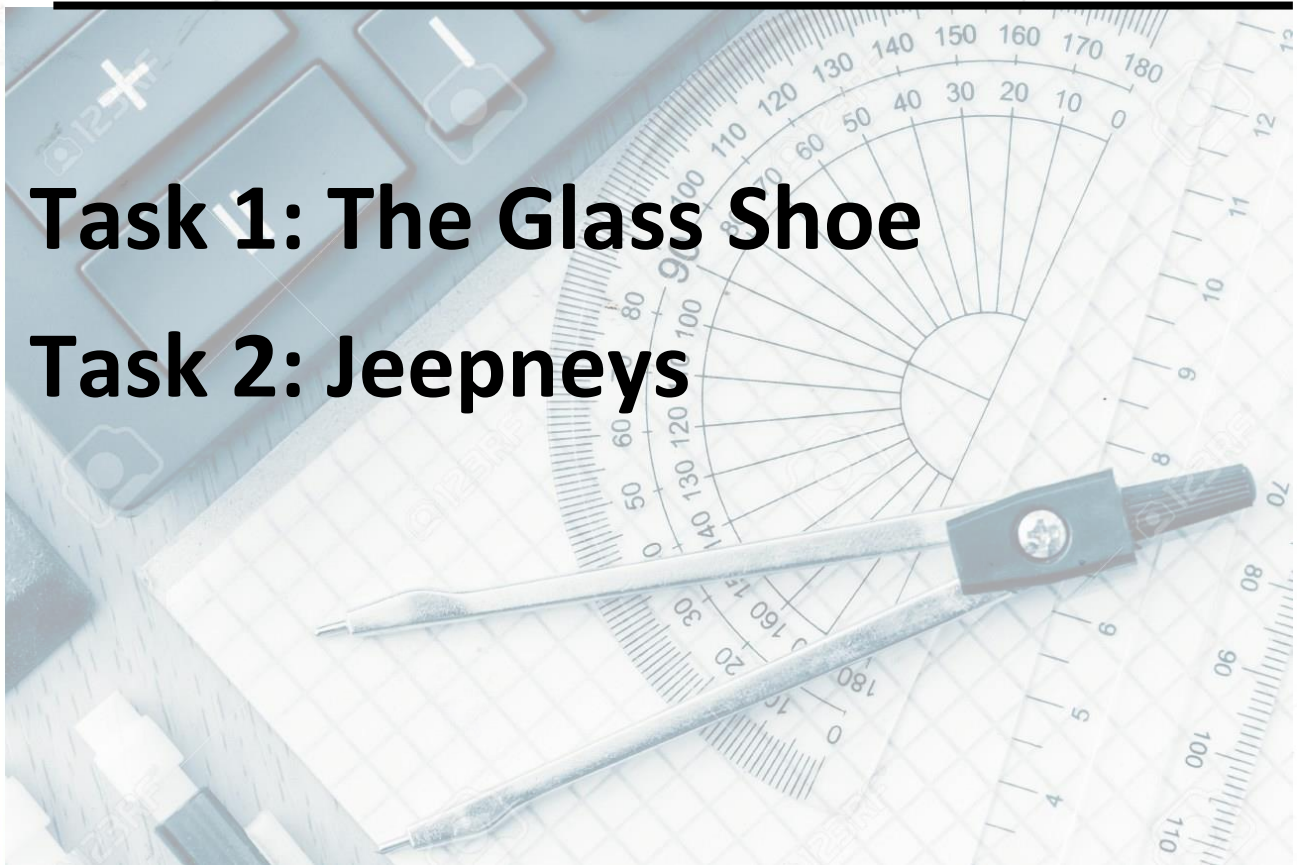


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PERFORMANCE TASKS ON MATHEMATICAL MODELING IN GRADE 7

Task 1: The Glass Shoe
Task 2: Jeepneys





THE GLASS SHOE

Teacher's Guide – Getting Started

Purpose

As a child, you have heard the story of Cinderella. You have known that she left her glass shoe in the ball and this shoe was used by the prince to find her. According to several studies in USA and Japan, Cinderella has a very small feet of approximately 4 and half (euro size) and height of 5'3" (<https://glassslippershoeblog.com/2019/06/17/cinderellas-tiny-feet/>). Using your knowledge on Linear Equation find out who among your groupmates can be Cinderella?

Students will identify their height and shoe size. Through this, they will try to find the relationship of height and shoe size of each member. Using the data, they are going to find Cinderella among their groupmates.

Pre-requisite: Knowledge of measurement

Materials

Required: Measuring tape and shoe size

Suggested: Excel and GeoGebra

Optional: None

Objectives

1. Determine the relationship between the height and shoe size of a person.
2. Illustrate in linear equation the relationship between the height and shoe size of a person.

Learning Competencies

1. Translates English phrases to mathematical phrases and vice versa.
2. Interprets the meaning of a positive integer.
3. Evaluates algebraic expressions of given values of the variables.
4. Illustrates linear equation and inequality in one variable.
5. Finds the solution of linear equation or inequality in one variable.
6. Solves linear equation or inequality in one variable involving absolute value by: (a) graphing; and (b) algebraic methods.
7. Solves problems involving equations and inequalities in one variable.



THE GLASS SHOE

Student Name: _____ Date: _____

In the story Cinderella, Cinderella was a daughter of the Duke who died and was living with her step-mother and two step-sisters. She attended the ball in the palace with the help of her fairy Godmother who helped her by magically transforming her into a princess who wore a glass shoe. But she should not forget that she needed to come back before 12 o'clock or else the magic would disappear. At 12 o'clock she immediately run away but left one of her glass shoes. The prince is looking for Cinderella and his only clue is her glass shoe. According to several studies in USA and Japan, Cinderella has a very small feet of approximately 4 and half (euro size) ang and height of 5'3" (<https://glassslippershoeblog.com/2019/06/17/cinderellas-tiny-feet/>). Among your group members, who can be Cinderella? Can the prince find her?



Leading Question

What is the relationship between the height and shoe size?



THE GLASS SHOE

Student Name: _____ Date: _____

1. Record the height (cm) and shoe size (EUR) of each member of the group. How are the two variables related?
2. Compare the height and shoe size of each member of the group. What model can you use to illustrate the relationship between the two variables?
3. Does your model help you determine the shoe size of each member?
4. Who among your group can be Cinderella? Does Cinderella exist in real life? Does the prince have the certainty that the girl she will find is Cinderella? (Hint: Compare your shoe size and height to the shoe size or height of Cinderella.)



THE GLASS SHOE

Teacher's Guide – Possible Solutions

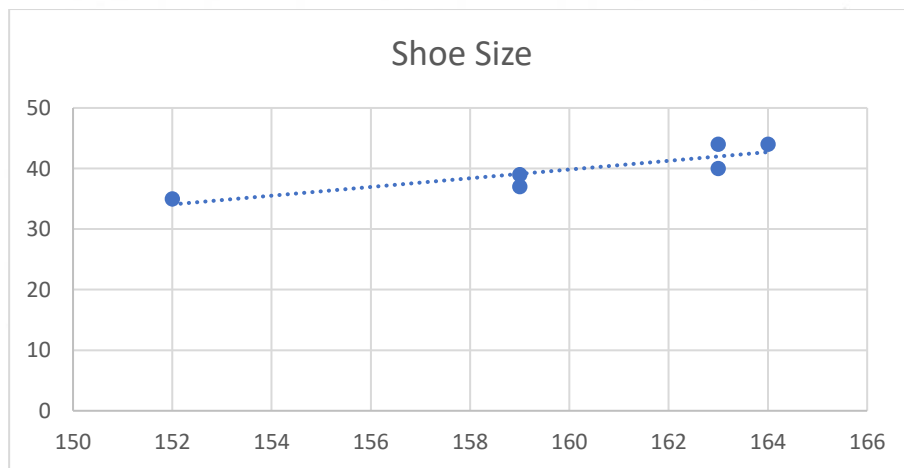
Please evaluate students' solution methods on the basis of mathematical validity.

1. The height and shoe size of each member are listed below.

Student	Height (cm)	Shoe Size (EUR)
A	164	44
B	163	44
C	159	39
D	163	40
E	159	37
F	152	35

In most cases, the taller the person is, the bigger the shoe size. On the other hand, the smaller the person is the smaller the shoe size.

2. The height and shoe size of a person are directly related. The taller the person is the bigger the shoe size.



The model that can be used in the problem is $y = 0.72x - 74.367$ where x is equal to 160, with an E of 1.362528.

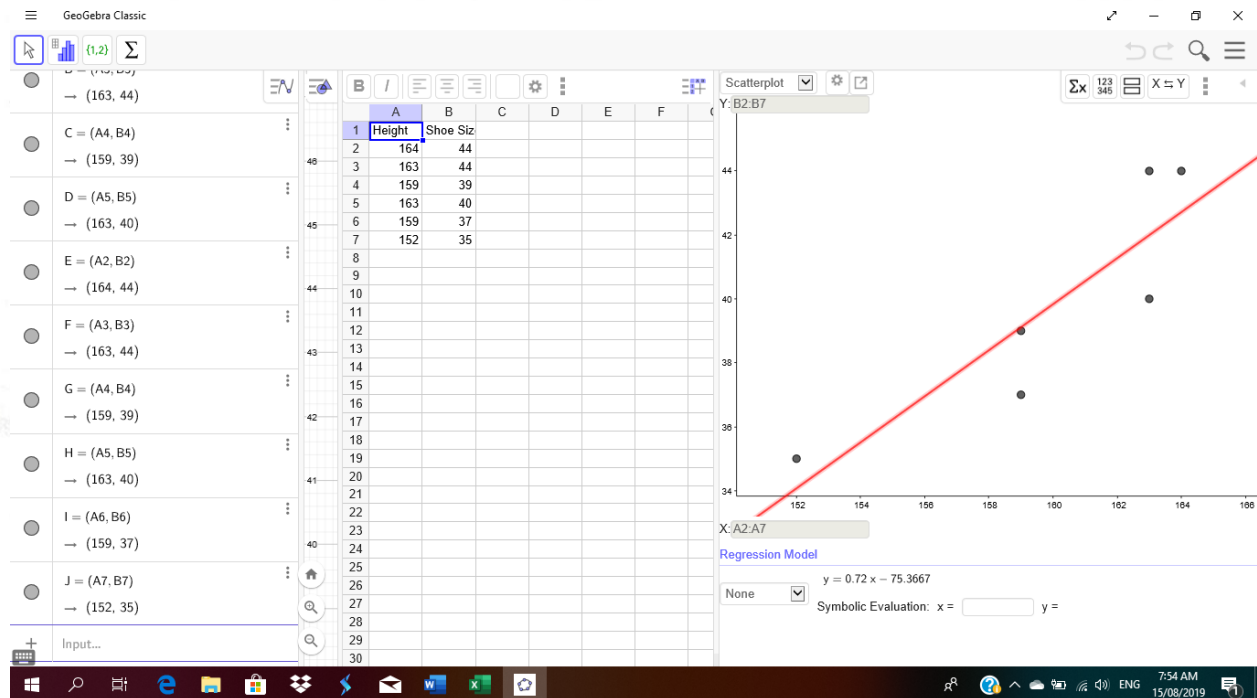
3. Yes. In the model $y = 0.72x - 74.367$, if you substitute x with the height then, the shoe size will be found. For example:

Height	Expected Shoe Size	Equation
--------	--------------------	----------



164	44	$y = 0.72 (164) - 74.367$ $y = 44$
163	44	$y = 0.72 (163) - 74.367$ $y = 44$

Another method to find the model is through GeoGebra. The model found is $y = 0.72x - 75.3667$ ($R^2 = 0.78$ and $SSE = 22.43$) which is almost the same with the solution find in excel.



4. Cinderella can exist in real life but there is no guarantee that the prince will find her with just the use of the glass shoe since many humans in the world have the same shoe size.



JEEPNEYS

Teacher's Guide – Getting Started

Purpose

As a Filipino, you are very familiar with jeepneys. It is the main transportation in the Philippines. Hence, you must know how much is the regular fare for a jeepney ride in your town. Your task is to find out how much the jeepney fare is from your house to your school.

Students will gather data outside the classroom to conduct a survey among the jeepney drivers to find out the fare in their location. Then, the students will use this information to create a model that will determine the fare from your house to school.

Pre-requisite: Knowledge of representing values in algebraic form

Materials

Required: None

Suggested: Excel and GeoGebra

Optional: None

Objectives

1. Identify the jeepney fare per kilometer in your location.
2. Determine the relationship between jeepney fare and distance travel in kilometer.
3. Create a model that determines the jeepney fare from your house to your school.

Learning Competencies

1. Differentiates algebraic expressions and equations.
2. Translates English sentences to mathematical sentences and vice versa.
3. Differentiates equations and inequalities.
4. Illustrates linear equation and inequality in one variable.
5. Finds the solution of linear equation or inequality in one variable.
6. Solves linear equation or inequality in one variable involving absolute value by: (a) graphing; and (b) algebraic methods.
7. Solves problems involving equations and inequalities in one variable.



JEEPNEYS

Student Name: _____ Date: _____

Jeepneys are unique means of transportation in the Philippines. They are made out of surplus jeeps left by the military troops. Having it extended, ornamented and accessorized. Jeepneys still remain the main method of transportation in the Philippines. They are found literally everywhere. In Pampanga, jeepneys are the most accessible means of transportation since taxi and LRTs are no where to be found. Moreover, despite, the increase in price of gasoline and diesel, it is still the most practical and the cheapest way to travel in the Philippines. The students are tasked to gather data from jeepney drivers to find out the fare in their location.



Leading Question

How much is your fare in a PUJ if you are going to travel from your house to school?



JEEPNEYS

Student Name: _____ Date: _____

1. Conduct a survey from jeepney drivers about the jeepney fare in your location. What is the jeepney fare per kilometer and for succeeding kilometers?
2. Compare the jeepney fare in each kilometer. What can you say about the fare from 1 km to 25 km?
3. What model can you use to determine the jeepney fare from your house to school?
4. Explain mathematically how knowing your model indicates the right jeepney fare.
5. What is the distance from your house to school? Using your model, find the fare when you travel using PUJ.



JEEPNEYS

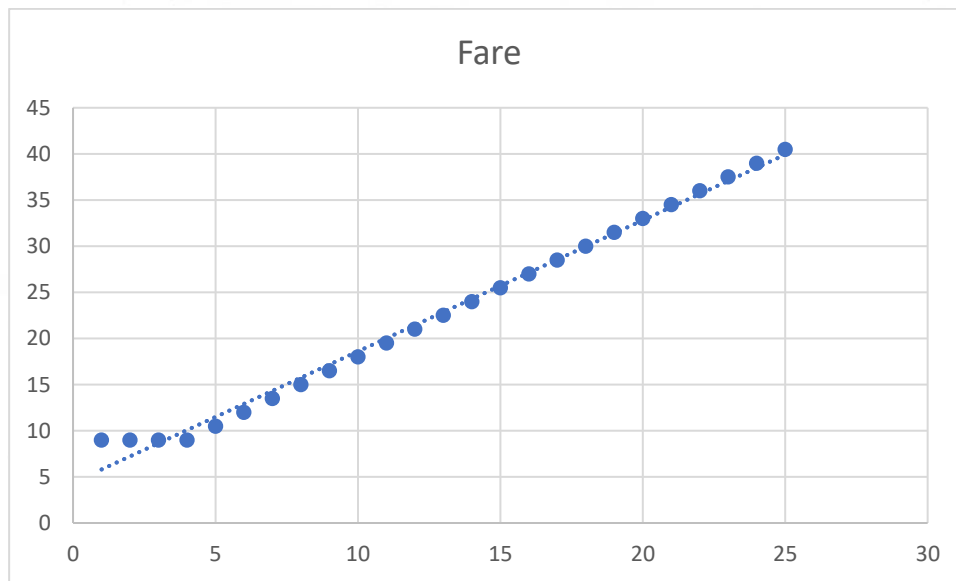
Teacher's Guide – Possible Solutions

Please evaluate students' solution methods on the basis of mathematical validity.

1. The fare per kilometer based on survey is the following:

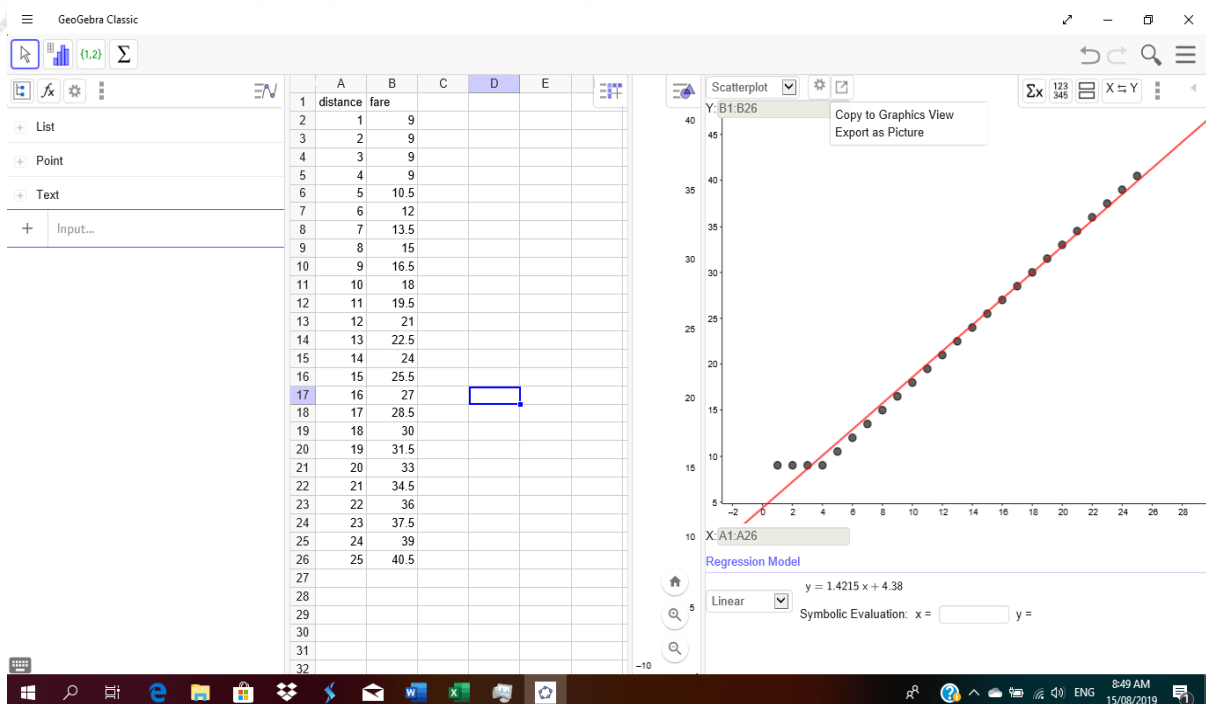
Distance (km)	Fare
1	9
2	9
3	9
4	9
5	10.5
6	12
7	13.5
8	15
9	16.5
10	18
11	19.5
12	21
13	22.5
14	24
15	25.5
16	27
17	28.5
18	30
19	31.5
20	33
21	34.5
22	36
23	37.5
24	39
25	40.5

2. The jeepney fare in 1 km is cheaper compare to the fare in 25 km. Also, as the travel is getting farther the fare is getting higher.
3. The jeepney fare from 1 km to 25 km is shown below.



The model that can be used to determine the jeepney fare based on distance (kilometer) is $y = 1.4215x + 4.38$, $E = 9.95$.

Another solution can be done through GeoGebra. The model using GeoGebra is $y = 1.4215x + 4.38$ ($R^2 = 0.99$ and $SSE = 9.95$) which is exactly the same with the model found in excel.



4. Yes. In the model $y = 1.4215x + 4.38$, the $E = 0.180030767$. Therefore, the error should be nearer to 0.



5. The distance between my house to school is 5 km. Using the model $y = 1.4215x + 4.38$, then the fare my house to school is 11.49 pesos.



PERFORMANCE TASKS ON MATHEMATICAL MODELING IN GRADE 8

A background image showing a collection of mathematical tools: a calculator, a ruler, a protractor, and a compass, all arranged on a light-colored surface.

Task 1: The Longest Jump Task 2: The Air Conditioner

THE LONGEST JUMP

Teacher's Guide – Getting Started

Purpose



In this performance task, students will determine if they can beat the Philippine record in long jump done in 2008 by Henry Dagmil for men's category and Marestella Sumang in 2016 for women's category. Moreover, they will identify if there is a relationship between body weight and the distance obtained in long jump through the experiment.

Students will use their knowledge on linear equation to model real – life situations, particularly on determining the relationship between weight and distance of the long jump.

Pre-requisite: Knowledge of measurement, polynomials and basic operations on polynomials

Materials

Required: Meter Stick, Meter tape, weighing scale, graphing paper, scientific calculator

Suggested: Excel

Optional: None

Objectives:

1. Identify the weight and distance of the long jump of each member.
2. Compare the distance of the long jump of the light and heavy members.
3. Identify if there is a relationship between the weight of a person and distance of its long jump.
4. Create a model that will determine the distance of the long jump based from the weight of the person.

Learning Competencies

1. Illustrates Linear Equation in two variables.
2. Illustrate the slope of a line.
3. Finds the slope of a line given two equations, points and graph.
4. Writes Linear equation $ax + by = c$ in the form $y = mx + b$ and vice versa.
5. graphs a linear equation given (a) any two points; (b) the x - and y - intercepts; (c) the slope and a point on the line.
6. Describes the graph of a linear equation in terms of its intercepts and slope.
7. Finds the equation of a line given (a) two points; (b) the slope and a point; (c) the slope and its intercepts.
8. solves problems involving linear equations in two variables.
9. Illustrates a system of linear equations in two variables.
10. Graphs a system of linear equations in two variables



THE LONGEST JUMP

Student Name: _____ Date: _____

The Philippine current record for long jump was recorded in the Philippine Amateur Track and Field Association (PATFA). As of PATFA (2018), the current record holder in the long jump are Henry Dagmil who jumped 7.99 meters last June 7, 2008 for men's category and Marestella Torres-Sunang, who jumped 6.72 meters in Kazakhstan in 2016 for women.

In ancient Greek, long jump was being done with halter masses, which weighs two to nine kilograms. In a study made by Powell (2002), results found that the best athletic performance was produced when the jumper held weights of about three kilograms in each hand; performance declined again when the weights reached about five or six kilograms. Swinging lightly weighed-down arms actually generates more power that is transferred to the legs upon take-off. Hence, in this performance task, you will find out if weight is a factor in long jump.



Leading Question

Given your weight, can you jump further than the world's current record in long jump?



THE LONGEST JUMP

Student Name: _____ Date: _____

1. Record in pounds (lbs) the weight of each member of the group.
2. Record the length in inches (inch) the distance of the jump of each member.
3. Is it possible to obtain zero weight and zero distance in a jump? Explain your answer.
4. Compare the weight and distance of the jump obtained by each member. What can you say about the weight and obtained distance? What model can you use to illustrate the relationship between two variables?
5. Explain mathematically how knowing your model indicates accurately the distance of the jump.
6. What is the ideal weight for men to surpass Henry Dagmill's record in long jump?
7. What is the ideal weight for women to surpass Marestella Torres – Sunang's record in long jump?
8. Given the longest distance your group obtained in the activity, is it still possible for you to jump farther? How?



THE LONGEST JUMP

Teacher's Guide – Possible Solutions

Please evaluate students' solution methods on the basis of mathematical validity.

1. The students will present the results of the task in this manner.

Student	Weight (lbs)
A	95
B	130
C	112
D	92
E	77
F	108

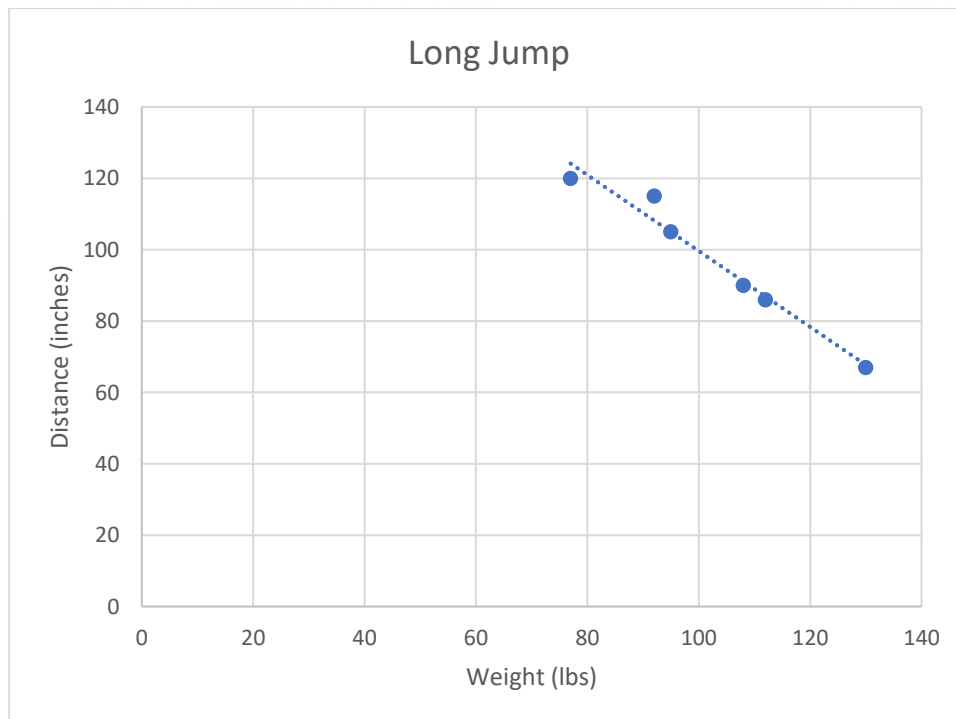
2. The students may present the results of the task in this form.

Student	Distance (inch)
A	105
B	69
C	86
D	115
E	120
F	90

The students may answer that the obtained distance is closer or far from the national's record by Dagmill and Sunang (depending on the gender of the jumper). They may also observe that some of them jump farther than other members of the group.

3. The students may use a table of values or a graph to see the possibility of zero weight and zero distance such as shown below.

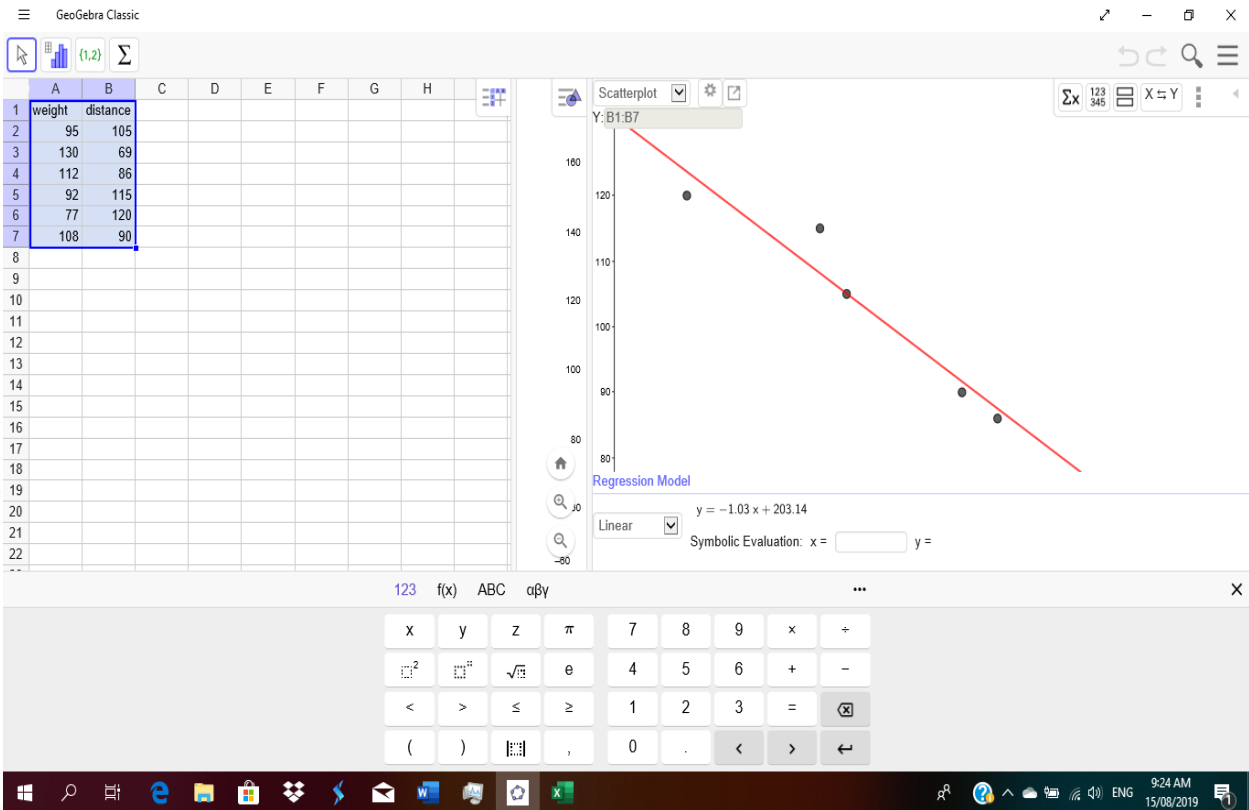
Weight in pounds	95	130	112	92	77	108
Distance in inches	105	69	86	115	120	90



The students may observe that the distance increases as weight decreases. Using the graph, the students may notice that the distance of the long jump is a straight line and seem to approach infinity. Therefore, it will not be equal to zero since there is no value of distance that is equal to zero. Also, it is impossible to have zero weight, since there is no human being that can weigh zero, it shows that there is no human body.

4. In this particular question, the students may observe that the distance of the long jump depends on the weight of the jumper. Here, they can see that the distance (inch/es) is the dependent variable and the weight (lbs) is the independent variable. They can use the concept of linear equation and slope intercept form $y = mx + b$. Hence, using the excel, the model that represents the relationship between the distance of the jump and weight is $y = -0.9382x + 191.34$ where x is the weight (lbs) and y is the distance (inch). Other students may use table or graph to show the relationship between the two variables.

Through the use of GeoGebra, a model can also be found. The model is $y = -1.03x + 203.14$ ($R^2 = 0.97$ and $SSE = 65.07$).



5. Yes. In the model $y = -0.9382x + 191.34$, if you substitute x with the weight then, the distance of the long jump will be found. For example:

Weight (lbs)	Distance (inches)	Equation
95	105	$y = -0.9382(95) + 191.34$ $y = 102$
120	69	$y = -0.9382(120) + 191.34$ $y = 69$

6. According to the result of the experiment, the lighter the person is the longer the distance he can jumped. On the other hand, the heavier the person is the shorter the distance he can jumped. Hence, in order to surpass Henry Dagmil's record of 314.57 inches in long jump, the person should be lighter than him. Thus, the model will be equal to $y < -0.9382x + 191.34$, where y is the distance (inches) and x is the weight (pounds). Therefore, $314.57 \text{ inches} < -0.9382x + 191.34$, since the distance needed to be jumped by the person who wants to surpass Dagmil's record should be greater than 314. 57. But, according to the



model the weight of the person who can surpass Dagmil's record is negative, specifically -131.35 lbs and there is no one that can have a negative weight, for there is no human being who can exist without weight at all. Hence, it is only through practice that a man can surpass Dagmil's record, and not by losing or gaining weight.

7. According to the result of the experiment, the lighter the person is the longer the distance she can jump, on the other hand, the heavier the person is the shorter the distance she can jump. Hence, in order to surpass Marestella Torres - Sumang's record of 264.57 inches in long jump, the person should be lighter than Sumang. Using the model, $y < -0.9382x + 191.34$ where x is the weight (pounds) and y is the distance (inches). Therefore, the model will be $264.57 \text{ inches} < -0.9382x + 191.34$, since the distance jumped by the person who wants to surpass Sumang's record should be greater than 264.57 inches. But, using the model the weight of the person who can surpass Sumang's record is a negative value that weighs -78.05. Unfortunately, there is no person who can exist without a weight, furthermore, a negative weight. Hence, it is only through practice that a woman can surpass Sumang's record, and not by losing or gaining weight.
8. Given their distance in long jump, the students' answers will vary depending on their capacity to jump. Since distance is not solely dependent on weight, students may answer that they need to practice harder to jump farther.



THE AIR CONDITIONER

Teacher's Guide – Getting Started

Purpose

To begin, explain the situation of the classroom ventilation to the Homeroom Parent Teacher Association (HPTA) to convince them to have an air conditioner inside the classroom. Your task is to help the HPTA convince the principal that it will not cost too much electric consumption with concrete evidence.

Students will be asked to use their knowledge on Linear equation to compute for the electric consumption of an air conditioner in a year and its corresponding amount. Through their knowledge on polynomials and linear equations they will determine the most cost-efficient air conditioner to buy.

Pre-requisite: Knowledge on polynomials and relations, linear equation

Materials

Required: Activity sheet, Newspaper ads, Air conditioner brochure or manual, scientific calculator

Suggested: excel

Optional: Internet access, printer (to find energy consumption (kwh) of air conditioners).

Objectives

1. Determine the relationship of electric consumption in kwh and electric bill in peso.
2. Create a model that will determine the electric bill using the electric consumption.
3. Find the most cost-efficient air conditioner for your classroom.

Learning Competencies

1. Illustrates Linear Equation in two variables.
2. Solves problems involving linear equations in two variables.



THE AIR CONDITIONER

Student Name: _____ Date: _____

Every year the Homeroom Parent – teacher Association of your class has a project. This year the HPTA officers decided to buy an air conditioner as their project. To help the HPTA convince the school principal to approved the project your class decided to help the HPTA by surveying the best energy saver air conditioner to buy. Help them convince the principal to approve their project.



Leading Question

Which brand of air conditioner is the best to buy to save energy consumption?



THE AIR CONDITIONER

Student Name: _____ Date: _____

1. Choose five brands of air conditioner that are suitable for 60 square meter classroom. List their energy consumption in kw/hr, and units needed.
2. Compare their energy consumption and units needed. What can you say about the two variables?
3. What model can you use to find the energy consumption and energy cost in a year of each air conditioner? Explain your answer.
4. How much is the energy consumption and energy cost in a year of each air conditioner? Explain your answer.
5. Given the data, can you now convince your school principal to approve your HPTA project? Explain your answer. (Hint: Compare the electric consumption using the most cost-efficient air conditioner and electric fan.)



THE AIR CONDITIONER

Teacher's Guide – Possible Solutions

Please evaluate students' solution methods on the basis of mathematical validity.

1. The air conditioners' units needed and electric consumption (kwh)

Air conditioner	Cooling area (square feet)	Units needed	Electric consumption kwh
Brand 1	63	1	4 kwh
Brand 2	30	2	2.9 kwh
Brand 3	23	3	2.3 kwh
Brand 4	16	4	2 kwh
Brand 5	14	5	1.8 kwh

2. As the number of units needed increases, the electric consumption of each unit decreases. This means that if the cooling area of an air conditioner is smaller, then the kwh is also smaller but in contrast the number of units needed also increases.
3. The cost of energy consumption E in the Philippines kwh is 10.219 pesos, number of school hours is 8 and number of school days is 201. According the distribution system operators of electric companies (Meralco, Pelco, etc.), in order to find the energy cost in a year the units needed U will be multiplied to the kwh K times number of school hours H and number of days in a school year S . Therefore, $E = UKHS$. Through substitution $E = UK(8)(201)$. To find the energy cost C multiplied the energy consumption and the cost of kwh in the Philippines which is 10.219 pesos.
4. The energy consumption in a year can be found using the model $E = UKHS$. On the other hand, the model used in getting the energy cost in a year is $C = E(10.219)$

Energy cost in a Month

Air Conditioner	Energy Consumption in a month (kwh)	Energy Cost in a month (Pesos)
Brand A	536	5,477.38
Brand B	777.2	7,942.21
Brand C	804	8,216.08



Brand D	1, 072	10, 954. 77
Brand E	1, 206	12, 324.11
Energy cost in a Year		
Air Conditioner	Energy Consumption in a year (kwh)	Energy Cost in a year (Pesos)
Brand A	6,432	65,728.61
Brand B	9,326.4	95,306.48
Brand C	9,648	98,592.91
Brand D	12,864	131,457.22
Brand E	14,472	147,889.37

5. They can use the result of their survey about the energy cost in a year of an air conditioner to explain to the principal that it is not that expensive to use an air conditioner for the ventilation through the use of Brand A. Furthermore, comparing it to the use of electric fan inside the classroom. Using the model $E = UKHS$, for the energy consumption in a year using electric fans where there are 4 units, 1.2 kwh, 8 hrs and 201 days. Therefore, By substitution;

$$E = 4(1.2)(8)(201)$$

Therefore,

$$E = 7, 718.4$$

The energy consumption of an electric fan inside the classroom is 7, 718.4. Multiplying it to the price of electricity in the Philippines per kwh 10.219 pesos. Therefore, the amount of electric consumption in a year using electric fans is 78, 874.33 pesos. Compared to the 65,728.61 pesos in a year of Brand A, Brand A is much cost-efficient.



PERFORMANCE TASKS ON MATHEMATICAL MODELING IN GRADE 9

Task 1: Kick the Ball
Task 2: The Candle





KICK THE BALL

Teacher's Guide – Getting Started

Purpose

In the football game, a player needs to be adept with kicking. In order to be a good football player, one needs to practice kicking a ball against a wall. The height of the goal post is 8 feet. In this performance task, the students need to use their knowledge on quadratic equations to find out the maximum height of the kicked ball to assure a goal.

Students work towards determining a good model that follows the height of the kicked ball against the wall. They are encouraged to focus on what variables are important to consider as well as the domain of the function. Students are then given measurements about the height of the goal in a football game.

Pre-requisite: Knowledge of graphing and linear equation and mathematical modeling

Materials

Required: Soccer ball and measuring tape, stop watch

Suggested: Graphing Calculators, excel and GeoGebra

Optional: None

Objectives

1. Determine the relationship of the trajectory time and height of the kicked ball.
2. Identify the best trajectory time of the kicked ball to assure a goal.
3. Create a model that illustrates the relationship of the two variables.

Learning Competencies

1. Illustrates Quadratic equation.
2. Solves quadratic equations by: (a) extracting square roots; (b) factoring; (c) completing the square; and (d) using the quadratic formula.
3. Characterizes the roots of a quadratic equation using the discriminant.
4. Describes the relationship between the coefficients and the roots of a quadratic equation.
5. Solves equations transformable to quadratic equations (including rational algebraic equations).
6. solves problems involving quadratic equations and rational algebraic equations.



KICK THE BALL

Student Name: _____ Date: _____

Football is a game played by two teams of eleven players with a ball that may not be touched with the hands or arms during play except by the goalkeepers. The object of the game is to score goals by kicking or heading the ball into the opponents' goal. Some of the basics that kids can start learning is controlling the ball and kicking the ball. Control is necessary if a player wants to be talented. If you're not able to control the ball, success in soccer could be harder than it has to be.

One of the drills used in practice by aspiring football player is kicking a ball against a wall. The benefits of young kids going out and kicking a ball against the wall are endless. This is a great drill because it allows a player to work on numerous aspects of the game. The beauty of kicking the ball against the wall is the unpredictability of how the ball will come back. Striking the ball at different speeds and heights will teach kids that they must adjust their bodies to control the ball. Your task is to kick the ball and measure its time (in seconds) before it reaches the wall and how high the ball when it collided with the wall.



Leading Question

What is the maximum height of the kicked football to have a goal in an official football game?



KICK THE BALL

Student Name: _____ Date: _____

1. Record the height of the ball after the kick and the time in seconds it will take for the ball to reach its maximum height. What can you say about the trajectory time and height of the ball?
2. Is it possible to obtain a height with zero seconds? Explain your answer.
3. Compare the height of the kicked ball and trajectory time of each member. What can you say about the two variables?
4. Create a model that will illustrate the relationship of the two variables.
5. Using your model, find the trajectory time of the ball needed to reach the goal. Explain your answer.
6. Given the highest kick your group obtained in the activity, is it still possible for you to kick the ball higher? How?

KICK THE BALL



Teacher's Guide – Possible Solutions

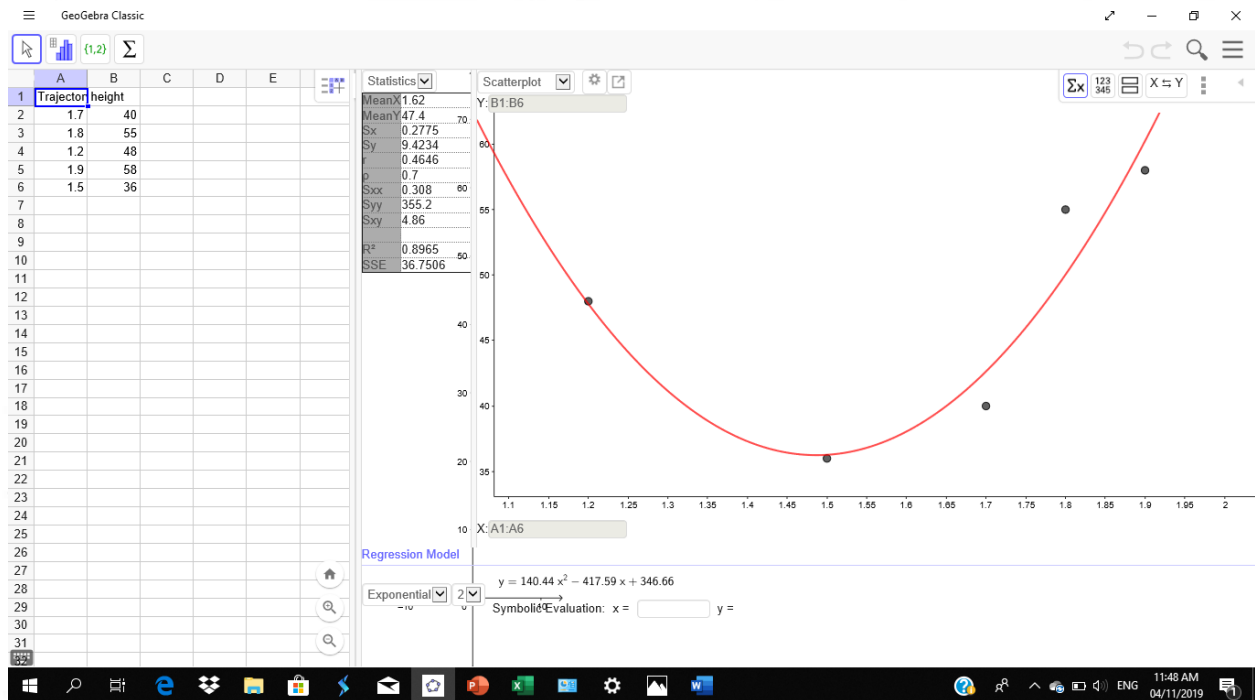
Please evaluate students' solution methods on the basis of mathematical validity.

1. The flight of the football is uniformly continuous (i.e., smooth) and its path follows that of a parabolic curve.

Student	Trajectory Time (seconds) (x)	Height (inches) (y)
A	1.7	40
B	1.8	55
C	1.2	48
D	1.9	58
E	1.5	36

2. It is impossible to have a height in zero seconds since it means that the ball is motionless and did not move.
3. The trajectory time of the kicked ball may not exceed to 2 seconds. Also, while doing the experiment the ball creates a parabolic shape after it bounces against the wall. Moreover, the maximum height of the ball before it reached the wall varies for each member.
4. Using the Microsoft office excel, the model found is $y = 167.74x^2 - 496.77x + 404.89$, where x is the time in seconds and y is the height of the ball.

Through the use of GeoGebra, the model is $y = 140.44x^2 - 417.59x + 346.66$ ($R^2 = 0.90$ and $SSE = 36.75$).



5. The model to be used is $y = 140.44x^2 - 417.59x + 346.66$, where y is the maximum height of the ball after the kick, and x is the time it travels to attain its maximum height.

Since the height of the goal post is 96 inches, therefore the maximum height of the ball after the kick should not be more than 96 inches.

Hence, the model will be,

$$y < 167.74x^2 - 496.77x + 404.89$$

to make sure the ball will enter the post. Thereafter, using Addition Property of Equality the equation will be,

$$0 < 167.74x^2 - 496.77x + 404.78 - 96.$$

Subsequently, by addition of like terms,

$$0 < 167.74x^2 - 496.77x + 308.78$$

Later on, using the Quadratic formula $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, by substitution,

$$x = \frac{-(-496.77) \pm \sqrt{(-496.77)^2 - 4(167.74)(308.78)}}{2(167.74)}.$$

By performing the operations, the values of x are 2.07 and 0.88.

Therefore, by Quadratic Inequalities, there are three possible solutions $(\infty, 2.07)$ $(2.07, 0.88)$ and $(0.88, -\infty)$. Through substitution, the only solution that can satisfy the



condition is (2.07, 0.88). Therefore, the time in seconds of the ball to bounce on the wall after a kick is between 2.07 and 0.88.

6. Practice makes perfect, in order for the ball to reach higher, one must practice harder. Also, based on the gathered data, as the longer trajectory time of the ball, the higher the possibility that it will reach higher. Hence, practice to make the ball stay longer on air before it reaches the intended place.



THE CANDLE

Teacher's Guide – Getting Started

Purpose

Black out is a situation at night where there is a temporary loss of electricity. In order to survive a night without electricity, Filipinos use candle. A candle is a molded or dipped mass of wax containing a wick that may be burned to give light. Through a candle, a night without electricity can be survived but these candles vary in length and width. In this performance task, the students will find how many candles with a length of 30 cm and diameter of 3cm can last for 8 hours.

In this Performance task, the students will do an experiment to determine how long a candle with different length but the same width can last. Through this experiment the students will look for the height of a candle that can last for 8 hours using a model.

Pre-requisite: Problem solving in elementary algebra and utilizing open-ended questioning in mathematics.

Materials

Required: candles with same width but different lengths and matches

Suggested: Excel

Optional: None

Objectives

1. Determine the relationship of the length of the candle and the time it takes to melt.
2. Create a model that determines the time it takes for a candle to melt based on its length.

Learning Competencies

1. Illustrates situations that involve the following variations: (a) direct; (b) inverse; (c) joint; (d) combined.
2. Translates into variation statement a relationship between two quantities given by: (a) a table of values; (b) a mathematical equation; (c) a graph, and vice versa.
3. Solves problems involving Variations.



THE CANDLE

Student Name: _____ Date: _____

Your barangay will experience a two-day black out. To be ready with the black out, you are going to buy a candle that can last for 8 hours. To choose the best one, measure the length of a burning candle with the same width and plot the length versus time.



Leading Question

How many candles with a length of 30cm and diameter of 3cm can last of 8 hours?



THE CANDLE

Student Name: _____ Date: _____

1. Find candle with length 10 cm, 15 cm, 20 cm, 25 cm and 30 cm with same width of 3 cm to compare. Light them and measure the length of time until they melt away.
2. Compare the candles' length of time until they melt away. What are the differences?
3. Create a model that will illustrate the relationship between the two variables.
4. Explain mathematically how knowing your model indicates the best length of candle.
5. Given the data you have collected, how many candles with a length of 30 cm and diameter of 3cm can last for 8 hours. Explain your answer.



THE CANDLE

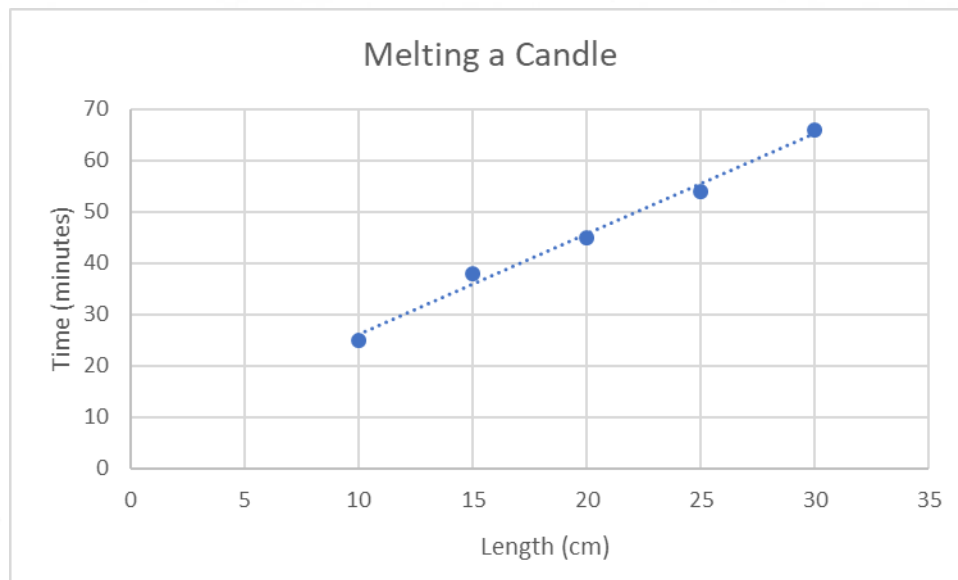
Teacher's Guide – Possible Solutions

Please evaluate students' solution methods on the basis of mathematical validity.

1. These are the list of candles with different length but with the same diameter of 3 cm.

Candle	Length (cm) (x)	Time (minutes) (y)
A	10	25
B	15	38
C	20	48
D	25	57
E	30	68

2. As the length of the candle increases, the time until it completely melts also increases. Hence, there is a direct variation or direct relationship between the length of the candle and its melting time.





3. Based on the experiment, there is a direct relationship between the length of the candle and the time until it melts. Hence, using direct variation, the length of the candle l varies directly to its melting time t . Therefore, $t = kl$, where k is constant. Using direct variation, the k varies for different length of candles. Hence, to get a k for all length of candles, the average of all k was solved which is 2.5 cm/sec. In conclusion, the model is $t = l(2.5)$, where k is the length of the candle and with a diameter of 3cm.

Length (x)	Time (y)	Constant k
10	25	2.5
15	38	2.53333
20	48	2.4
25	57	2.28
30	68	2.266667

4. Using the formula in finding the error, $\sqrt{\Sigma(Model - y)^2}$, the error found is 4.3.

Length	Time	K	Model	Ss
10	25	2.5	25	0
15	38	2.533333	37.995	0.005
20	48	2.4	50	2
25	57	2.28	62.5	5.5
30	68	2.266667	75	7

5. The length of a candle that can last for 8 hours or 480 minutes with a width of 3 cm can be found using the model $y = l(2.5)$, where y is the time until the candle completely melts and l is the length of the candle.

By substitution,

$$480 = l(2.5)$$

By Division Property of Equality (DPE),

$$l = 192 \text{ cm}$$

Since, there is no candle with a length of 192 cm, let us determine how many candles with the length of 30cm and diameter of 3 cm can last for 8 hours by dividing 192 by 30. Therefore, 7 candles with a length of 30cm and circumference of 3cm will be needed during an 8- hour black out.



PERFORMANCE TASKS ON MATHEMATICAL MODELING IN GRADE 10



Task 1: Population of San Esteban
Task 2: Savings Account



POPULATION OF SAN ESTEBAN

Purpose

Projection of any country's population plays a significant role in the planning as well as in the decision making for the socio-economic and demographic development. The students are task to determine the population of your barangay San Esteban ten years from now. They will conduct a census on the number of populations of their assigned barangay. Thereafter, they will try to predict the possible population growth rate or decline in five years.

Students will work towards determining a good model that follows the pattern of the growth or decline of the population in San Esteban, Macabebe, Pampanga.

Pre-requisite: Knowledge of linear equation

Materials

Required: Excel, census of your barangay population

Suggested: Calculators

Optional: None

Objectives

1. Identify the pattern of the population growth or decline in barangay San Esteban, Macabebe, Pampanga.
2. Create a model that follows the pattern of the growth or decline of the population in San Esteban, Macabebe, Pampanga.

Learning Competencies

1. Illustrates polynomial equations.
2. Solves polynomial equations.
3. Illustrates polynomial functions.
4. Graphs polynomial functions.
5. Solves problems involving polynomial functions.



POPULATION OF SAN ESTEBAN

Student Name: _____ Date: _____

Projection of any country's population plays a significant role in the planning as well as in the decision making for the socio-economic and demographic development. Famous for its name "ALACAN", the barangay San Esteban catered a processing plant producing branded liquors under the ownership of the Cojuangcos'. Inhabitants of barangay San Esteban are of different origins since the latter is near the Province of Bulacan and Bataan. San Esteban is an island found in Macabebe, Pampanga which is accessible by boats. The population of San Esteban grew from 3,251 in 1990 to 5,002 in 2015, an increase of 1,751 people. The latest census figures in 2015 denote a positive growth rate of 3.46%, or an increase of 819 people, from the previous population of 4,183 in 2010. Is it possible to estimate the population of barangay San Esteban in 10 years?



Table 1. Population of San Esteban 1990 - 2015

Census date	Population
1990	3,251
1995	3,491
2000	3,897
2005	4, 183
2010	4, 602
2015	5,002

Leading Question

Given the previous data, can you estimate the population of barangay San Esteban in 10 years?



POPULATION OF SAN ESTEBAN

Student Name: _____ Date: _____

1. Compare the population of barangay San Esteban from 1990 to 2015. What can you say about the population from 1990 to 2015?
2. Given the data, what model can you use to estimate the population of barangay San Esteban from 1990 - 2015?
3. Conduct a survey and determine the present population from 2016 - 2019 of barangay San Esteban, Macabebe, Pampanga.
4. Compare the population of barangay San Esteban in 2015 and its present population. What can you say about the two populations? Conjure the population in 2015 – 2019 using your model.
5. Compare the population of barangay San Esteban throughout the years from 1990 to 2019. What can you say about the population?
6. Given the data you have collected, what can you say about the population of barangay San Esteban in five years? 10 years? What is the estimated population of barangay San Esteban in five years? 10 years?
7. Do you think your model will always work? Do you think your model will work in other barangays?

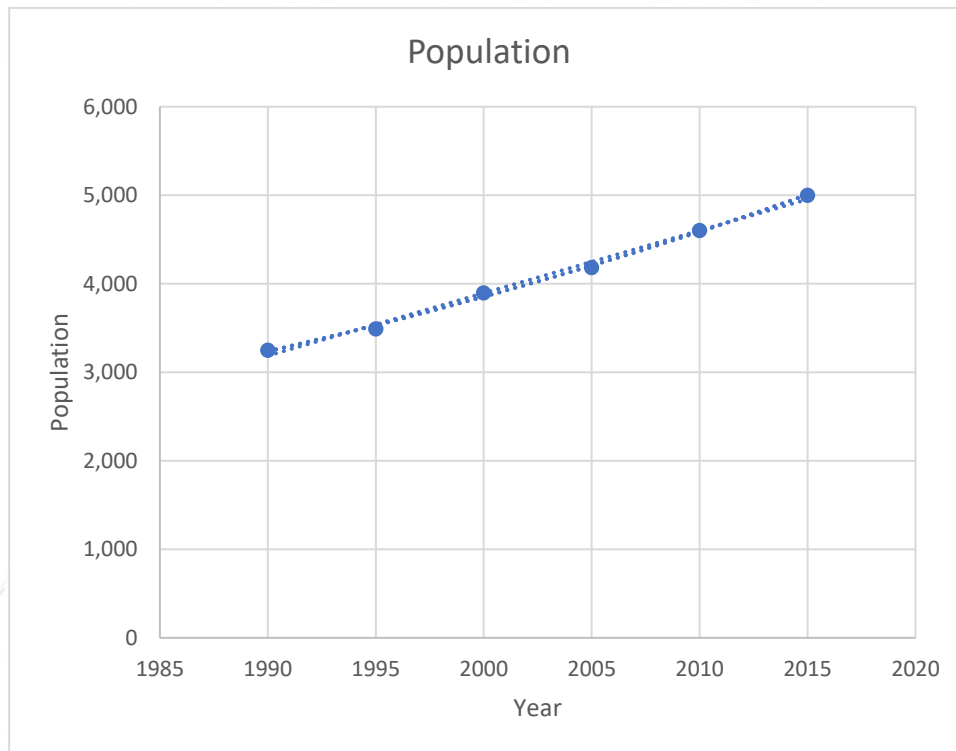


POPULATION OF SAN ESTEBAN

Teacher's Guide – Possible Solutions

Please evaluate students' solution methods on the basis of mathematical validity.

1. Population of Barangay San Esteban from 1990 to 2015.

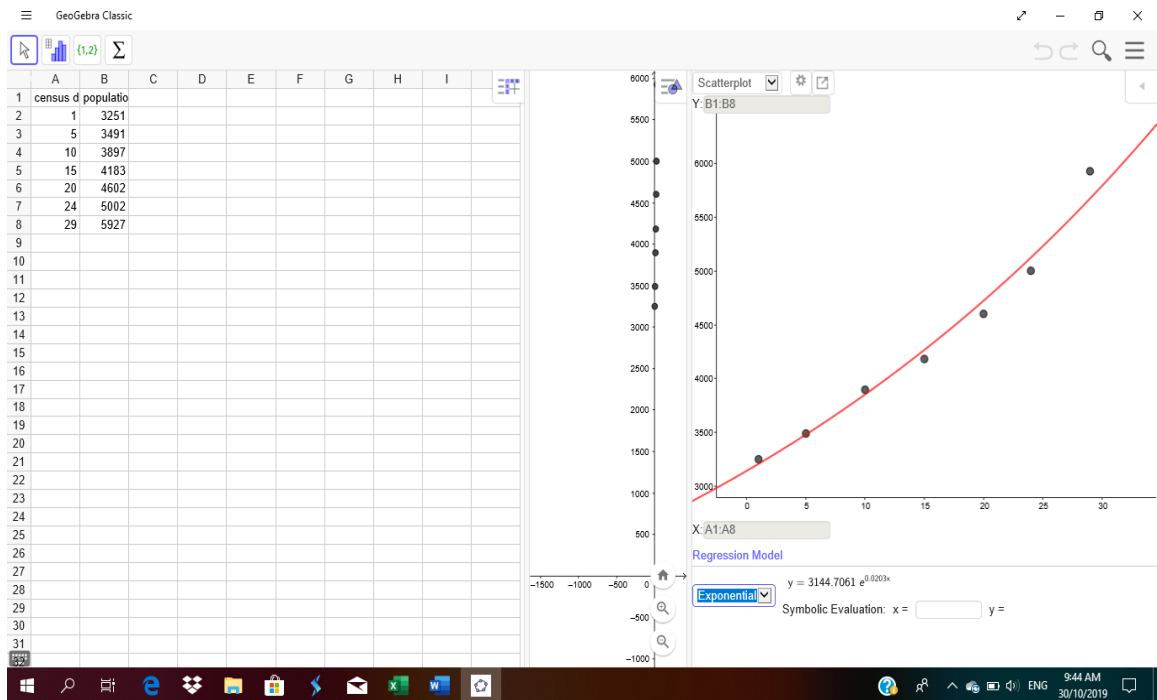


The population of barangay San Esteban is continuously increasing. From 1990 to 1995 it increases by 7%, then in 1995 to 2000 it increases by 12 %, after from 2000 to 2005, the population increases by 7%, from 2005 to 2010, a 10% increase of population has happened and from 2010 to 2015, the population increases by 8%. There is no decline of population in 25 years.

2. Given the data the students collected, they may say that the population will increase or decrease. They may come up to similar exponential function model $f(x) = 3183e^{0.0195x}$

where x is the number of years and $f(x)$ is the population.

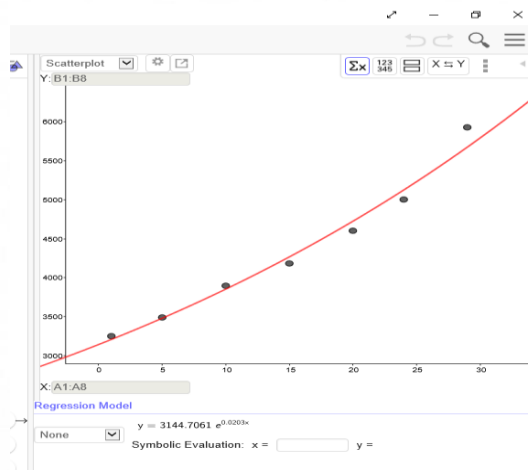
Using GeoGebra, the model for the population is $f(x) = 3144.71e^{0.02x}$. ($R^2 = 0.98$ and $SSE = 104,934.74$)



3. Students answer may vary on their census.

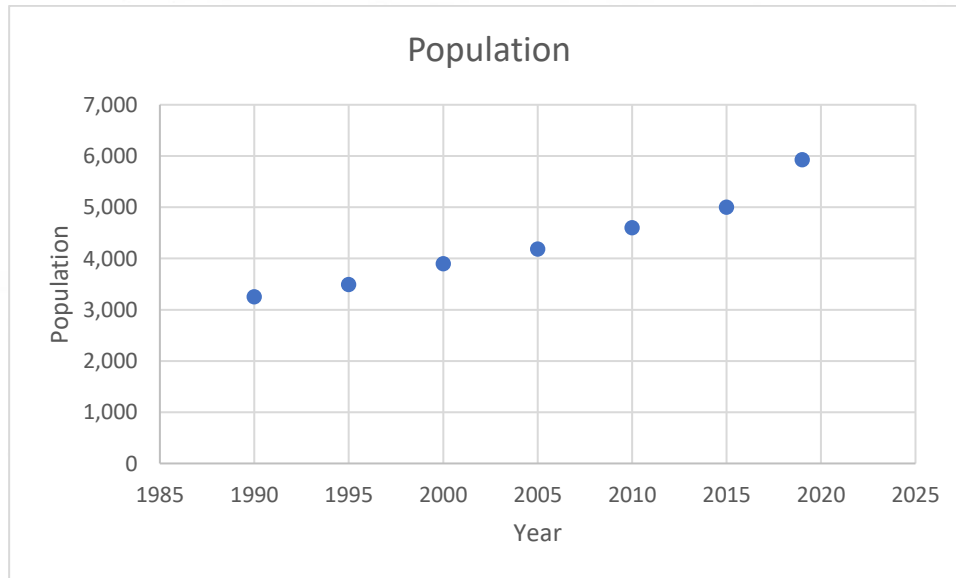
Year	Population
2019	5927

4. Population in barangay San Esteban 2015 and 2019.



The population of barangay San Esteban increases at 18% from 2015 to 2019. The population from 5,002 in 2015 became 5,927 in just 4 years. This is the highest increase of population in 29 years.

5. Population in barangay San Esteban from 1990 to 2019.



The population of San Esteban in 29 years never decreases. Furthermore, the increase rate every five years is getting higher. Thus, in five to 10 years the population of San Esteban, Macabebe, Pampanga will increase even more.

6. The population in 2024, 5 years from now is $f(x) = 3183e^{0.0195x}$, then $f(x) = 3183e^{0.0195(34)} = 5,963$. It increases by 16% of the prior population. Then after 10 years, in 2029, the population will become 6,547 and will increase by 21% from 2019.
7. The model may not work with other barangays, since the population in other barangays is differ from San Esteban. Furthermore, the error found is 72.55, that shows that the model is not that accurate. They can check it using an available data from other barangays.

Census date	Population	Model	ss
1	8. 3,251	9. 3219.28	10. 1006.133
5	11. 3,491	12. 3469.05	13. 481.7807
10	14. 3,897	15. 3808.688	16. 7799.016
15	17. 4,183	18. 4181.578	19. 2.023116
20	20. 4,602	21. 4590.975	22. 121.5487
24	23. 5,002	24. 4947.169	25. 3006.43
29	26. 5,927	27. 5431.522	28. 245498.7



SAVINGS ACCOUNT

Teacher's Guide – Getting Started

Purpose

In this Performance – based Assessment Task, the students are going to be part of the decision of their parents in choosing a banks' savings account in preparation of their higher education.

Students are asked to determine the best bank's savings account to invest to prepare in the incoming expenses in their college education.

Pre-requisite: Problem solving in elementary algebra and utilizing open-ended questioning in mathematics.

Materials

Required: Brochure of different banks savings account

Suggested: GeoGebra, Excel, internet

Optional: None

Objectives

1. Identify different banks offer for savings account.
2. Determine amongst the banks the best savings account.
3. Create a model to determine the compounded money in two years.

Learning Competencies

1. Illustrates polynomial equations.
2. Solves polynomial equations.
3. Illustrates polynomial functions.
4. Graphs polynomial functions.
5. Solves problems involving polynomial functions.



SAVINGS ACCOUNT

Student Name: _____ Date: _____

Once you have finished senior high school, you may want to pursue your college education. Although many students struggle to finance their studies, your personal financial situation should not prevent you from going to college, since an investment in your personal education will most likely pay off itself. Various statistics have shown that college educated people have higher average salaries.

In the Philippines, higher education is now free from tuition fee in state universities and colleges. Although, higher education is now considered less expensive, miscellaneous expenses are still needed to be provided. Hence, preparing for college life is a must. Therefore, many parents find the need for savings account to provide for their child's higher education.

A savings account is a deposit account held at a bank or another financial institution where you can deposit a sum of money and get a modest interest rate. It is an interest-bearing deposit account, which serves as one of the safest ways to invest your hard-earned money. As a junior high school student, how can you help your parent to find the most profitable savings account?



Leading Question

What savings account will you choose to gain the most profit after 2 years?



SAVINGS ACCOUNT

Student Name: _____ Date: _____

1. List six banks in your city, in terms of initial deposit, maintaining balance, and interest rate.
2. The compound interest can be expressed as $A = P(1 + \frac{r}{n})^{nt}$ where A is the amount, P is the principal amount, r is the interest rate, n is the number of times interest is compounded per year and T is the time in years. How can you compute the compounded money obtained by each bank? What mathematical model will you use to compute your compounded money in two years?
3. Compare the interest rate and the compounded money in each bank for two years. What can you say about the two variables? What model can you use to illustrate the relationship between the two variables?
4. Which bank's savings account will you choose that will give you the highest profit in two years? Explain your answer.
5. How much will be the compounded amount of 100, 000 pesos in Bank A to F?



SAVINGS ACCOUNT

Teacher's Guide – Possible Solutions

Please evaluate students' solution methods on the basis of mathematical validity.

1. The Six bank accounts near the barangay.

Bank Name	Interest Rate (Monthly Deposit)	Initial Deposit
Bank A	5%	25,000
Bank B	0.15%	1,000
Bank C	1.25%	500
Bank D	0.05%	5000
Bank E	0.50%	500
Bank F	3%	25,000

2. The students may use the standard formula of compound interest, $A = P(1 + \frac{r}{n})^{nt}$, to come up with a new formula since time in years (2) and number of times in a year compounded are constant. By substitution, $A = P(1 + \frac{r}{2})^{12(2)}$, to compute their compounded money. Their computations can be of this form: If $P = 25,000$ and $r = .001$, then $A = 25,000(1 + \frac{.05}{12})^{12(2)} = 27,623.53$

Other students may express their answers in tabular form:

Bank Name	Interest Rate (Monthly Deposit)	Initial Deposit	$A = P(1 + \frac{r}{2})^{12(2)}$
A	5%	25,000	27,623.53
B	0.15%	1,000	1,001.00
C	1.25%	500	501.03
D	0.05%	5000	5,005.00
E	0.50%	500	505.02
F	3%	25,000	25,150.43



3. In this particular question, the students may observe that the compounded amount depends on the interest rate. Here they can say that the independent variable is the interest rate and the dependent variable is the compounded amount. They may use x to represent the interest rate. Then the compounded amount can be represented as $A(x)$, as follows $A(x) = P(1 + \frac{x}{2})^{12(2)}$. Other students may use table or graph to show the relationship between the two variables.
4. The best savings account offered by the banks are from bank A, C and F since they have the highest interest rate.

Bank Name	Interest Rate (Monthly Deposit)	Initial Deposit	$A = P(1 + \frac{r}{2})^{12(2)}$
A	5%	25,000	27, 623.53
C	1.25%	500	501.03
F	3%	25,000	25, 150.43

5. Using the model $A = P(1 + \frac{r}{2})^{12(2)}$, the compounded amount of 100,000 is shown below.

Bank Name	Interest Rate (Monthly Deposit)	Cash Deposit	$A = P(1 + \frac{r}{2})^{12(2)}$
A	5%	100,000	180,872.60
C	1.25%	100,000	116,129.20
F	3%	100,000	142,950.28



APPENDIX B

THE STANDARDIZED RUBRIC FOR MM BY GAIMME



The Standardized Rubric for Mathematical Modeling by GAIMME (2015)

Direction: Please select a value (1-5) reflection the extent to which you agree with the given statement.

Indicator	3	2	1	0	SCORE
Define the Modeling Problem	Concise problem that indicates exactly what the output of the model will be and, if appropriate, identifies the audience and/or perspective of the moderator. Statement is presented early in the paper	Problem statement is easily identifiable but not precise or consistent with other statements in paper.	Problem statement is difficult to understand or is buried in the text.	No problem statement is given.	
Building the Model: Make assumptions and acknowledge limitations	Primary assumptions used to develop the model are clearly identified, easy-to-read and well justified. Limitations due to simplification are stated when appropriate.	Primary assumptions are noted; justification or readability is lacking.	Assumptions and justification exist but are difficult to identify in the text	No assumptions or justification for lack of assumption is provided.	
Building the Model: Define variable and identify parameters	Notes and rationalizes the need for primary factors that influence the phenomena	Important variables and parameters are listed properly but without	Variables/ parameters are within barely mentioned or hard for the reader to	No variables or parameters are identified.	



	being modeled in a readable format; proper units are specified.	sufficient explanation.	identify in the text.		
Solution: Models uses meaningful Mathematics	Provides a readable glimpse into the Mathematical method(s) used to solve the problem. Plausible approach and outcomes are presented.	Mathematical approach is stated, but aspects of the method(s) are inconsistent, difficult to understand or incomplete.	Model is stated and/or contains fixable mathematical error.	Model is not presented or contains significant error.	
Solution: Results are accessible to the audience	Clearly presents a solution that is consistent with the original problem statement. If appropriate, a useful visual aid/graphic is included.	Answer is stated, but aspects of the solution(s) are inconsistent, difficult to understand or incomplete.	Answer is given without contextual background	Solution is bot provided.	
Analysis and Assessment of Model	The viability and reliability of the math modeling solutions are addressed.	Addressed, but the analysis is lacking proper dimensionality.	Some analysis I provided but without any sense of perspective.	No analysis or assessment of model is included in the write-up. Incorrect Mathematics used in analysis.	
Writing Style and Organization	Correct spelling and grammar are	Multiple spelling formatting or	Significant disregard for common	Complete disregard for common	



	used throughout. Paper is well formatted and enjoyable to read. Visual aids (if appropriate) are well chosen and easy to interpret	grammatical errors. Visual aids are missing key readability features or do not clearly connect to the solutions.	spelling, grammatical and mathematical rules.	spelling, grammatical and Mathematical rules.	
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COMMENTS AND SUGGESTIONS:

Evaluator's Signature over Printed Name



The Standardized Rubric for Mathematical Modeling by GAIMME (2015)

Presentation made by a group:

Please select a value (1-5) reflection the extent to which you agree with the given statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Score
I understood the presenting team's interpretation of the question.						
All stated assumptions were adequately justified.						
The model's strengths and weaknesses were addressed.						
Appropriate Mathematics was used to create the model.						
A final solution was clearly presented.						
The Mathematics model produced a plausible result.						
Visual aids were easy to read and understand.						
The team addressed the alternative scenarios and/or the need for future work.						
I enjoyed the presentation; the presenter(s) held my attention for the full extent of the talk.						
I would like to learn more about this team's solution method.						

What is one question you would like to ask this group?

Additional questions or comments:

Note: Will be given to the members of different groups (member of the presenting groups will not be allowed to rate themselves).



APPENDIX C

LETTER TO THE

VALIDATORS



February 14, 2019

Sir/Ma'am:

Warm greetings!

The undersigned is a graduate student of Philippine Normal University with a degree of Masters of Arts in Education major in Mathematics. Currently, I am writing my thesis paper entitled ***“Development and Validation of Performance Tasks using Mathematical Modeling”***. In accordance with this, I am humbly asking your permission to be one of my validators who will evaluate the developed Performance Tasks that will be used by secondary Math teachers as a means of evaluating students learning.

I am looking forward that my request would merit your positive response.

Thank you and God bless!

Respectfully Yours,

VANESSA P. PANGAN

Noted by:

ROSIE L. CONDE, Ph. D.

Thesis Adviser



APPENDIX D

LETTER TO THE PRINCIPAL OF SAN ESTEBAN HIGH SCHOOL



March 4, 2019

Jojkyle L. Carencia
Principal I
San Esteban High School
Macabebe, Pampanga

Sir:

Greetings of peace and prosperity!

I would like to asked for your permission to conduct a research entitled “Development and Validation of Performance Tasks using Mathematical Modeling”. It is in accordance with the undersigned final requirement in her Master degree with a degree of Master of Arts in Education major in Mathematics at Philippine Normal University.

The researcher aimed to develop and validate a performance tasks in Mathematics using Mathematical Modeling. It is in lieu with the DepEd order no. 8 series of 2015, where in 40% of the grade of the students is from Performance Task. Hence, the researcher seeks for your permission to gather data from the Grade 10 students of your school through trying out the developed performance tasks.

Your positive response will be much appreciated. Thank you very much and Godspeed!

Sincerely yours,

Vanessa P. Pangan
SST – I



APPENDIX E

INFORMED

CONSENT

FORM



Informed Consent Form to Participate in the Research Study

Development and Validation of Performance Tasks using Mathematical Modeling

Vanessa P. Pangan

MAEd – Mathematics

Philippine Normal University

panganvanessa14@gmail.com

A. PURPOSE AND BACKGROUND

You are being asked to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. Please read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information.

The purpose of this study is to develop and validate a performance tasks using Mathematical Modeling. This study focuses on developing performance task using MM because its integration into everyday life at school is necessary to inculcate in the mind of students that Mathematics can be incorporated with reality. Moreover, the researcher wanted to give awareness to teachers about MM since it is not yet integrated into day to day classroom discussion so far.

B. PROCEDURE

If you agree to participate in this research study, the developed performance tasks using Mathematical modeling will be sent to you together with the survey questionnaire to be used to validate the developed instructional material. You will be given an ample time to read and validate the developed instructional material.

C. RISKS

The research may take your time to read and validate the developed instructional material and may result to your inconvenience.



D. CONFIDENTIALITY

The records from this study will be kept as confidential as possible. No individual identities will be used in any reports or publications resulting from the study. All questionnaires will be given codes and stored separately from any names or other direct identification of participants. Research information will be kept in locked files at all times. Only the researcher will have access to the files and survey questionnaire, and only those with an essential need to see names or other identifying information will have access to that particular file. After the study is completed, the result will be disseminated to all the validators.

E. BENEFITS OF PARTICIPATION

There will be no direct benefit to you from participating in this research study. The anticipated benefit of your participation in this study is to help secondary school teachers in integrating Mathematical modeling in their performance task assessment. Furthermore, to help students see the application of Mathematics in real life through the developed performance tasks using Mathematical Modeling.

F. VOLUNTARY PARTICIPATION

Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign a consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

G. QUESTIONS

If you have questions at any time about this study, or you experience adverse effects as the result of participating in this study, you may contact the researcher whose contact



Philippine Normal University
The National Center for Teacher Education
College of Graduate Studies and Teacher education Research
Graduate Research Office
Manila



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information is provided on the first page. If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the Educational Policy Research and Development Center (EPRDC) of Philippine Normal University.

CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Participant's signature Catherine G. Manansala Date March 6, 2019

Researcher's signature [Signature] Date March 6, 2019



APPENDIX F

EXPERTS

VALIDATION

CHECKLIST



Expert's Validation Checklist

Title: Development and Validation of Performance Task using Mathematical Modeling

Researcher: Vanessa P. Pangan

Course: Master of Arts in Education Major in Mathematics

School: Philippine Normal University

Direction: Below is a list of criteria for validating the Performance Task using Mathematical Modeling. Please put a check mark (/) to your corresponding rate of each item using the equivalent 4-point scale (1-needs improvement; 2-fair; 3- highly satisfactory; and 4-outstanding).

Content Validity	4	3	2	1
A. Established Goals and Standard/Objectives				
1. Objectives are clearly stated.				
2. Objectives are specific, measurable and attainable.				
3. Objectives are well-planned, formulated and organized.				
4. Objectives are relevant to the set of competencies in the curriculum guide.				
5. Objectives embrace important ideas that can be achieved through genuine application of knowledge and skills.				
B. Learning content, Knowledge and Skills				
1. Content/s are relevant to the defined objectives.				
2. Content/s are within the comprehension and interest of heterogenous class.				
3. Content/s are mathematically correct and accurate.				
4. Content/s are grammatically correct.				
5. Content/s demand the use of higher order thinking skills.				
6. Content/s enhance students Math Competence.				
7. Content/s encourage the use of different Mathematical Concept and Skills.				
C. Performance Tasks using Mathematical Modeling				
1. It involves a complex, real world, and authentic application of the identified knowledge, skill and understanding.				
2. It contains instruction that is clear to everyone.				
3. It engages and challenge students to find answers.				
4. It involves different concepts and ideas in Mathematics.				
5. It provides students a sense of accomplishment.				
6. It promotes collaborative learning.				
7. It involves creative and innovative application of concepts and skills.				
8. It allows students to demonstrate understanding with some choices, options or variety in the performance and products.				
9. It allows students to check, recheck and improve their work.				
10. It allows students to use various ways of solving the problems.				



Comment/s and Suggestion/s

Usefulness				
1. It motivates the students to learn Mathematics.				
2. It is very useful in developing students' interest and curiosity.				
3. It helps students develop critical thinking and problem solving.				
4. It utilizes practical application and real-life situations that students can relate.				
5. It allows the transfer of learning of concepts into real-life situations.				

Evaluator: _____

Position: _____

School: _____

Address: _____



APPENDIX G

SAMPLE ACCOMPLISHED EXPERT'S VALIDATION CHECKLIST



Expert's Validation Checklist

Title: Development and Validation of Performance Task using Mathematical Modeling

Researcher: Vanessa P. Pangan

Course: Master of Arts in Education Major in Mathematics

School: Philippine Normal University

Direction: Below is a list of criteria for validating the Performance Task using Mathematical Modeling. Please put a check mark (/) to your corresponding rate of each item using the equivalent 4-point scale (1-needs improvement; 2-fair; 3- highly satisfactory; and 4-outstanding).

Content Validity	4	3	2	1
A. Established Goals and Standard/Objectives				
1. Objectives are clearly stated.	/			
2. Objectives are specific, measurable and attainable.	/			
3. Objectives are well-planned, formulated and organized.	/			
4. Objectives are relevant to the set of competencies in the curriculum guide.	/			
5. Objectives embrace important ideas that can be achieved through genuine application of knowledge and skills.	/			
B. Learning Content, Knowledge and Skills				
1. Content are relevant to the defined objectives.	/			
2. Content are within the comprehension and interest of heterogenous class.		/		
3. Content demands the use of higher order thinking skills.	/			
4. Content enhance students Math Competence.	/			
5. Content encourages the use of different Mathematical Concept and Skills.	/			
C. Performance Tasks using Mathematical Modeling				
1. It involves a complex, real world, and authentic application of the identified knowledge, skill and understanding.	/			
2. It contains instruction that is clear to everyone.		/		
3. It engages and challenge students to find answers.	/			
4. It involves different concepts and ideas in Mathematics.	/			
5. It provides students a sense of accomplishment.	/			
6. It promotes collaborative learning.	/			
7. It involves creative and innovative application of concepts and skills.	/			
8. It allows students to demonstrate understanding with some choices, options or variety in the performance and products.	/			
9. It allows students to check, recheck and improve their work.	/			
10. It allows students to use various ways of solving the problems.	/			

Singular
or plural



Usefulness of the Performance Tasks

- | | | | |
|---|---|--|--|
| 1. It motivates the students to learn Mathematics. | / | | |
| 2. It is very useful in developing students' interest and curiosity. | / | | |
| 3. It helps students develop critical thinking and problem solving. | / | | |
| 4. It utilizes practical application and real-life situations that students can relate. | / | | |
| 5. It allows the transfer of learning of concepts into real-life situations. | / | | |

Comment/s and Suggestion/s

Evaluator: JANE P. VALENCIA

Position: EPC-1

School: DIVISION OF PAMP

Address: CITY OF ANTON



Usefulness of the Performance Tasks				
1. It motivates the students to learn Mathematics.	/			
2. It is very useful in developing students' interest and curiosity.	/			
3. It helps students develop critical thinking and problem solving.	/			
4. It utilizes practical application and real-life situations that students can relate.	/			
5. It allows the transfer of learning of concepts into real-life situations.	/			

Comment/s and Suggestion/s

There are no items pertaining to grammar & correct usage. I was distracted by general punctuation & grammatical errors in the tasks. These should be addressed to provide more clarity and scholarships to the work.

Evaluator: Gennera

Position: Math faculty

School: PNU

Address: Taft Avenue, Manila



APPENDIX H

CURRICULUM

VITAE



VANESSA P. PANGAN

#902 Sampaga San Vicente, Apalit, Pampanga

📞 0939-659-8397

panganvanessa14@gmail.com/pangan.vp@pnu.edu.ph



EDUCATIONAL BACKGROUND:

- Graduate **PHILIPPINE NORMAL UNIVERSITY**
MASTER OF ARTS IN EDUCATION
MAJOR IN MATHEMATICS
Manila
(2016-2020)
- College **BULACAN STATE UNIVERSITY**
BACHELOR OF SECONDARY EDUCATION
MAJOR IN MATHEMATICS
City of Malolos, Bulacan
(2011-2015)
- Secondary **APALIT HIGH SCHOOL**
Sulipan, Apalit, Pampanga
(2007-2011)
VALEDICTORIAN
- Primary **SAMPAGA ELEMENTARY SCHOOL**
Sampaga, Apalit, Pampanga
(2000-2007)
SALUTATORIAN

CIVIL SERVICE ELIGIBILITY

- **LICENSURE EXAMINATION FOR TEACHERS**
81.40
SEPTEMBER 27, 2015

SEMINARS

- ✓ **FIELD STUDY 1, 2, 3**
BULACAN STATE UNIVERSITY



- 23rd of JUNE 2013
- ✓ **OUTCOMES – BASED EDUCATION TOWARDS QUALITY INSTRUCTION**
 - **PHILIPPINE ASSOCIATION FOR TEACHERS AND EDUCATORS (PAFTE)**
BULACAN STATE UNIVERSITY
 - 13th of NOVEMBER 2014
- ✓ **2015 INSERVICE TRAINING FOR JHS TEACHERS IN PRIVATE SCHOOLS**
 - **FUND FOR ASSISTANCE TO PRIVATE EDUCATION (FAPE)**
 - April 14 – 16, 2019
- ✓ **CURRICULUM DEVELOPMENT AND BASIC FACILITATION**
 - **DON HONORIO VENTURA TECHNOLOGICAL STATE UNIVERSITY**
 - April 27 – 29, 2015
- ✓ **ASSESSMENT ON THE K-12 CURRICULUM AND UNDERSTANDING BY DESIGN**
 - **PHOENIX PUBLISHING HOUSE**
 - May 20 – 21, 2015
- ✓ **2015 CEAP NATIONAL CONVENTION**
 - **CATHOLIC EDUCATION ASSOCIATION OF THE PHILIPPINES**
 - September 21 – 25 2015
- ✓ **PRIVATE SCHOOL ANNUAL SEMINAR WORKSHOP**
 - **PAMPANGA ASSOCIATION OF PRIVATE SCHOOL PRINCIPALS AND ASSISTANT PRINCIPALS**
 - May 28 – 30, 2016
- ✓ **HONING THE COMPETENCIES OF THE 21ST CENTURY LEARNERS**
 - **PHILIPPINE ASSOCIATION FOR TEACHERS AND EDUCATORS (PAFTE)**
 - February 2, 2016
- ✓ **STRENGTHENING EDUCATIONAL LEADERSHIP TOWARDS A TRANSFORMED LEARNING COMMUNITY**
 - **PHOENIX PUBLISHING HOUSE**
 - April 11 – 19, 2016
- ✓ **2016 INSERVICE TRAINING FOR JHS TEACHERS IN PRIVATE SCHOOL**
 - **FUND FOR ASSISTANCE TO PRIVATE EDUCATION (FAPE)**
 - April 20 – 22, 2016
- ✓ **2016 CEAP NATIONAL CONVENTION**
 - **CATHOLIC EDUCATION ASSOCIATION OF THE PHILIPPINES**
 - September 28 – 30 2016
- ✓ **11TH BIENNIAL CONFERENCE OF THE PHILIPPINE COUNCIL OF MATHEMATICS TEACHER EDUCATORS (MATHTED), INC.**
 - **MATHTED**



- October 19 – 21, 2017
- ✓ **DIVISION TRAINING WORKSHOP IN MATHEMATICS ACROSS TEACHING HEURISTICS (SECONDARY LEVEL)**
 - DEPARTMENT OF EDUCATION (DEPED)
 - DEMONSTRATION TEACHER
 - November 22 – 24, 2017
- ✓ **GENDER AND DEVELOPMENT SEMINAR: EMPOWERING TEACHERS IN A CHALLENGING ENVIRONMENT**
 - DEPARTMENT OF EDUCATION (DEPED)
 - April 23, 24 – May 28, 2018
- ✓ **3RD INTERNATIONAL CONGRESS ON ACTION RESEARCH, ACTION LEARNING (ARAL 2018)**
 - DE LA SALLE UNIVERSITY
 - PAPER AND POSTER PRESENTER
 - May 24 – 26, 2018
- ✓ **REGIONAL K TO 10 MASS TRAINING OF TEACHERS (MTOT) ON CRITICAL CONTENT (MATHEMATICS 8)**
 - DEPARTMENT OF EDUCATION (DEPED)
 - DEMONSTRATION TEACHER
 - June 5 – 16, 2018
- ✓ **ITEACH: INNOVATION AND TECHNOLOGY – ENHANCED ACTIVITIES FOR CREATIVE HABITS IN MATHEMATICS**
 - DEPARTMENT OF EDUCATION (DEPED)
 - October 25, 26 and 29, 2018
- ✓ **DIVISION WIDE CAPACITY BUILDING RESEARCH SEMINAR**
 - DEPARTMENT OF EDUCATION (DEPED)
 - December 17 – 18, 2018
- ✓ **STRATAGEMS IN MATHEMATICS**
 - DEPARTMENT OF EDUCATION (DEPED)
 - May 15 – 17, 2019
- ✓ **PEDAGOGICAL RETOOLING IN MATHEMATICS LANGUAGE AND SCIENCES**
 - DEPARTMENT OF EDUCATION (DEPED)
 - May 20 – 22, 2019
- ✓ **STRATEGIES + TECHNOLOGIES WORKSHOP IN TEACHING THE LEAST MASTERED SKILLS IN MATHEMATICS**
 - DEPARTMENT OF EDUCATION
 - September 7, 2019
- ✓ **12TH BIENNIAL CONFERENCE OF THE PHILIPPINE COUNCIL OF MATHEMATICS TEACHER EDUCATORS (MATHTED), INC.**
 - MATHTED
 - PAPER PRESENTER



- October 24 – 26, 2019

Work Experience

✓ **Junior High School Teacher**

San Esteban High School
Macabebe, Pampanga
(2017-present)

✓ **Junior and Senior High School Teacher**

St. Nicholas Academy:CCEI
Macabebe, Pampanga
(2015-2017)