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THE USE OF ARTS IN THE DEVELOPMENT AND VALIDATION OF A PROTOTYPE CONSTRUCTIVIST-ORIENTED LEARNING PACKAGE IN SECONDARY MATHEMATICS

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Abstract

With the system-wide implementation of backward design instructional framework vis-à-vis the K+12 system in the Philippine basic education level, curriculum and content specialists are challenged to contribute their share in the design and development of learning plans and packages that ensure transferability of students' learning. Such tall order creates an instructional chasm which calls for more prototyping efforts in the light of constructivist principles. Anchored on Sternberg's triarchic theory of intelligence and Instructional Systems Design, this materials preparation endeavor attempted to develop and validate a prototype learning package in mathematics with a view to promoting a culture of understanding and transfer in mathematics classroom using technology.

Keywords: Secondary Mathematics, Constructivism, Authentic Tasks, Transfer of Learning, Arts

1. Introduction and purpose

Recent reform efforts in mathematics have taken constructivism as their theoretical underpinning. As a philosophy, it claims that the individual must have an active role and background knowledge in constructing new cognitive structures (Kesercioglu, Balim, & Evrekli, 2009). In a constructivist classroom, students use their schemata or previous experiences to build their own knowledge and understanding. Moreover, it fundamentally assumes that learners construct understanding through interactions with the physical and/or social environment (Demirci, 2010). Thus, a constructivist teacher acts as a facilitator (Isikoglu, Basturk, & Karaca, 2009; Doolittle, 1999; Vygotsky, 1978; cited in Nayir, Yildirim, & Kostur, 2009) and provides students with appropriate learning environment that would allow them to hypothesize, predict, manipulate objects, pose questions, research, investigate, imagine, invent (Isikoglu, Basturk, Karaca, & 2009), and solve meaningful, open-ended, challenging problems (Fox, 2001).

As envisioned by the National Council of Teachers of Mathematics (NCTM, 1989, 1991, 1995, 2000), mathematics classrooms are expected to have teachers who are capable of engaging students in rich, meaningful tasks as part of a coherent curriculum; capitalizing on students' thinking, shared orally and in writing, to guide the classroom community's exploration of important mathematical ideas; and gathering information from multiple sources as they assess students' understanding of mathematical ideas (Peressin, Borko, Romagnano, Knuth, & Willis, 2004). Goldin (1990), for his part, posited a view of mathematical learning as occurring most effectively through constructivist strategies such as guided discovery, meaningful application and problem solving. Incorporation of the arts in mathematics classrooms is one effective tool to carry out these strategies (Wallace, Abbott, & Blary, 2007). The arts, which include music, movement, art and drama, are necessary components of the contemporary curriculum that significantly contribute to mathematical understanding and application (Sloboda, 2001; cited in Hirsh, 2010). Articles from the Journal of Mathematics and the Arts studied on the utilization of the different forms of arts in mathematics such as the use of Gothic architecture in teaching calculus (Huber, 2009), students' artistic visualizations in demonstrating group theory (Harker, 2009), music and poetry in permutations, patterns and algebra (Fenton, 2009; Glaz & Liang, 2009). Ethnomathematics or the study of culture and mathematics evidently presented the use of material and non-material culture in learning mathematical concepts (Gerdes, 2005; Were, 2003). Technical skills, visual thinking skills and creativity in the arts infused into the mathematics classroom help more students reach their full mathematical potential (Hirsh, 2010). The arts can offer key entry points into math lessons, can provide opportunities to develop, explore, and assess math skills (Gardner, 2006; cited in Hirsh, 2010).

Toward this end, teachers should be equipped with appropriate curriculum materials necessary to carry out meaningful and successful teaching-learning process. Hence, there is a need for an effective policy structure and implementing framework that would advance teacher preparation, specifically on materials preparation.

The introduction of the Understanding by Design (UbD) teaching framework in the Philippine secondary education in 2010 has challenged the delivery of curriculum content across learning areas. Teachers are now required to spend a great deal of preparation. Curricular guidance, such as teacher-training seminars, dialogues, inter and intra visitations and mentoring should be provided for teachers' understanding of the new framework. Cognizant of what a constructivist view of learning requires, this framework shall alter the way mathematics is taught and learned. One pressing aspect of the environment is the use of contextualized situations wherein teachers should provide challenging tasks that are relevant to the students' world and daily life having the potential to increase students' interest in mathematics, which in turn may enhance achievement (Cai, 2000; Hattie, Biggs & Purdie, 1996; Hoek, van den Eden & Terwel, 1999; cited in Kramarski, Mevarech, & Arami, 2000). With this framework, students aim to construct mathematical meanings with the help of their concrete experiences and intuitions and intend to create a learning environment where they are mentally and physically active (Gokcek, 2009). Evidently, it differs from the content-structured curriculum. Rather than being organized around a traditional disciplinary structure, this curriculum is organized around tasks (Sherin, Edelson, & Brown, 2000). Selection of these tasks should be aligned with the particular content breadth and depth goals of the subject matter. Hence, as part of this curriculum reform, there is a need to design, develop and validate curriculum materials which can effectively guide teachers as they perform their roles in a highly constructivist classroom.

There is a growing body of research that aims to elucidate on the vital role of curriculum materials in the teaching-learning process. Educators and researchers emphasized that curriculum materials should promote student learning as well as teacher learning. In line with the task-structured curriculum, Coskun, Tosun, and Macaroglu (2009), for their paper, averred that teachers should use appropriate materials to make students' learning process concrete, meaningful, lasting and engaging. Moreover, as an integral element in the teachers' daily work and instructional enactment, the availability of appropriate materials support teachers' learning of subject matter (Ball & Cohen, 1996; Heaton, 2000; Schneider & Krajcik, 2002; Wang & Paine, 2003; cited in Davis & Krajcik, 2005). If curriculum materials are to serve the needs of both teachers and students, they must be accurate, complete and coherent in terms of content and effective in terms of pedagogy – with good representations of content, a clear purpose for learning, and multiple opportunities for students to explain ideas (Davis & Krajcik, 2005).

It is against the foregoing context that this paper was conceived. This materials preparation undertaking attempted to develop and validate a prototype learning package in high school mathematics. Said package was intended to be useful in facilitating and guiding students as they construct their own knowledge and perform transfer of learning. This involved authentic performance tasks, incorporating the different forms of arts, which would entail students' enduring understanding on mathematical concepts**.** Specifically, this paper contributes to mathematics education practice as it developed a prototype learning package in secondary mathematics.

2. Review of Literature and Research Questions

A large number of reform efforts have focused on constructing and fostering opportunities for teachers to learn more about mathematics teaching through activities such as exploring mathematics, examining students' understandings, analyzing pedagogical practices and critiquing their own teaching (Schifter, Bastable, & Russell, 1999; Stein, Smith, Henningsen, & Silver, 2000; Wilson & Berne, 1999). For example, Remillard and Bryans (2004) identified the roles that reform-oriented curricula might play in supporting teacher learning. Their findings suggested that reform efforts should include assisting teachers in the development and utilization of these new curriculum materials.

Further, a number of researchers and educators have noted the vital role of curriculum materials as agents of instructional improvement. In their paper, Ball and Cohen (1996) emphasized that design and spread of curriculum material is one of the oldest strategies for attempting to influence classroom instruction. They added that curriculum designers aim to create particular kinds of learning experiences for students. Hence, a more systematic approach to designing significant learning experiences, often referred to as the "backward design process," has been popularized by Wiggins and McTighe in 1998 (Allen & Tanner, 2007). This framework starts with the identification of the desired results (Stage 1), then proceeds with the determination of acceptable evidences (Stage 2) and lastly, the planning of learning experiences and instruction (Stage 3).

Enduring Understanding

In their book, Wiggins and McTighe (2005) defined enduring understanding as the specific inferences which have lasting value beyond the classroom. Allen and Tanner (2007) added that it does not only encompass big ideas at the heart of a given discipline, but also those ideas that have value beyond the classroom – knowledge and skills that will inform students' thoughts and actions when they graduate from school. They also noted that these are the ideas and processes with a broad intellectual focus and with the most potential for motivating student interest and engagement. The emphasis on enduring understanding had been a recent topic on several studies. According to Haddan (2005), teachers strive for understanding that survives beyond the end of the course, semester or program. She added that enduring understandings are active and students are involved in the objects of their learning, thinking about what they know and how it relates to the matter at hand, they integrate information with other information. Enduring understanding answers the question, ***"What concepts and constructs are essential for students to learn that have value beyond the classroom?***".

This is a very important question since it concerns the depth and breadth of knowledge that teachers and students must possess. Hence, in mathematics classrooms, enduring understanding provides essential questions addressing what important mathematical concepts students should carry with them outside the school.

Performance Task

According to Wiggins and McTighe (2005), understanding is revealed in performance. They defined performance task, also known as authentic task, as a task that uses one's knowledge to effectively act or bring to fruition a complex product that reveals one's knowledge and expertise. Using this performance or authentic task, the teacher acts as a facilitator of learning allowing students to construct their own understanding of the concepts, principles and theories. Previous studies have emphasized the significance of authentic tasks in achieving students' understanding.

Prawat (1998) stated that authentic tasks are important because knowledge construction is likely to occur when students have to deal with rich information and resolve cognitive conflicts, rather than applying readymade algorithms for solving standard tasks. Duke, Purcell-Gates, Hall and Tower (2006) added that authentic tasks mimic the activities people complete in settings outside of school. Learning environments that use real or authentic activities embedded in a context can provide a great deal of meaning to otherwise decontextualized facts and skills (Barab & Landa, 1997). Moreover, since authentic tasks contextualize students' learning, educators like Parsons and Ward (2011) emphasized that authentic tasks enhance students' motivation. However, in their paper, Kramarski, Mevarech and Arami (2000) posited that authentic tasks are rarely presented in mathematics classrooms. They also averred that the standard tasks customarily used by teachers are those which describe simplified situations involving ready-made algorithms that students have to apply in order to solve the problem. Many students, who are low as well as high achievers, face difficulties in solving authentic tasks (Verschaffel, Greer & De Corte, 2000; Kramarski, Mevarech & Liberman, 2001). For these reasons, teaching mathematics should redirect teachers to focus on solving authentic tasks. Constructivist teachers should develop authentic tasks that would enhance students' understanding. Performance or authentic tasks address the question, ***"What learning activities and experiences in mathematics classrooms engage students in their transfer of deep and lifelong learning?"***. Teachers should be innovative and creative in developing such tasks that would ensure students' successful learning.

Arts

The arts, which include music, movement, art and drama, are necessary components of the contemporary curriculum that significantly contribute to mathematical understanding and application (Sloboda, 2001; cited in Hirsh, 2010). Moreover, Hirsh (2010) averred that the arts are vital tools for the success of understanding and application of mathematical concepts in highly constructivist classrooms. One paper, by Huber (2009), describes an approach for instructors of single variable integral calculus courses in calculating the areas and volumes of Gothic structures like the *quintoacuto*arch. In his paper in 2010, Robert Rollings, a hands-on craftsman, showed his interest in geometry by demonstrating the five platonic solids namely tetrahedron, hexahedron, octahedron, dodecahedron and icosahedron using his chosen lath-turned wood to present models in an aesthetically pleasing and artistic way. Moreover, Ashton (2010) describes the integration of elements of Frank Lloyd Wright's architectural and decorative design in the study of symmetry, graph theory and function theory. Gage (2009) concentrated on regular floor tiling and other decorative patterns which he used to motivate a variety of mathematical discussions such as proportion and fractions, symmetry, and number patterns. From these, he derived algebraic formulae and programming, and investigations for students, through a wide age range, and which also help to see how math connects with reality. In Central Asia, one paper offered new opportunities to explore the topics of counting units and fractions for K-5, symmetry and geometry for grades 6-8 and algorithm for high school (Bier, 2009) using Turkmen carpets and other weavings. Similarly, proliferation of studies in ethnomathematics, pioneered by Braizilian Ubiratan D' Ambrosio in 1978, have been using artifacts and other artistic objects of learning as tools in understanding mathematical concepts (Were, 2003). Sternstein (2008) provided an extensive description of mathematical ideas and practices expressed in *Dan*, a tribal language (and culture and people) of the central Liberia, such as measuring rice to constructing round huts, games of chance, and telling time. Further, mathematical concepts were translated using mat and basket weaving in Northern Mozambique (Gerdes, 2005). Music and poetry included in the arts also served as vital tools in mathematics classroom. In his paper, Fenton (2009) suggested teaching permutations specifically on groups and cyclic groups through rhythm patterns. Glaz and Liang (2009) focused on the pedagogical use of poetry to ease students' difficulties with transition between word-problems representing natural phenomena, and the corresponding mathematical models in Introductory College Algebra and Mathematical Modelling. To some students, mathematical knowledge doesn't make sense in its traditional realm, but understanding unfolds when applied in different activities and domains (Hirsh, 2004). The technical skill, visual thinking, and creativity in the arts involve the ability of the students to manipulate materials to convey their intended purpose, the ability of students to understand and interpret visual information, and the ability of students to think flexibly and generate novel ideas, respectively (Wilson, 2009). Hence, constructivist mathematics teachers provide students the opportunity to draw pictures to solve problems, use graphic organizers, offer a choice of mathematical expression, and present information visually (Wilson, 2009). They can also invite students to create storyboards to illustrate steps to an algorithm, organizational charts, visual story problems and other visual representation of math concepts (Wilson, 2009). Teachers can take advantage of creativity in students through allowing brainstorming sessions, attribute listing, and through encouraging multiple problem solving perspectives (Wilson, 2009). Therefore, the use of the arts, both traditional and modern, can address question ***"What forms of arts can be incorporated in the authentic performance tasks in constructivist mathematics classrooms?"***.

Authentic Assessment

Wiggins and McTighe defined authentic assessment as an assessment composed of performance appraisals and activities designed to simulate or replicate important real world challenges in which realistic performance based testing should be implied. It emphasizes the practical application of tasks in the real-world settings. Assessment is very important since it serves as the basis of making decisions in the teaching-learning process. The fact that the right decisions can only be reached by solid information, which in turn can only be obtained through healthy assessment methods, is considered as the role of quality assessment in the educational system (Stiggins, Conklin & et al, 1992; cited in Nitko, 2004). Keyser and Howell (2008) averred that authenticity is the element of every successful assessment that resembles a real-world skill or activity and aligns itself with a learning outcome. Instructors should be able to grade results obtained through all assessment instruments and methods in the most objective manner possible (Gareis & Grant, 2008; cited in Nartgün, 2009). To achieve this, teachers should develop and use rubrics. According to Wiggins (1998), a rubric is a set of scoring guidelines for evaluating student work. Moreover, De Guzman (2007) defined rubrics as printed set of guidelines that distinguishes performances or products of different quality, portfolio or written compilation of students' outputs, and open-ended exercises that ask questions requiring students to give various responses. Highlighted by some researchers like Morell and Ackley (1999), rubrics help remove much of the guesswork in grading student performances and products, and keep teachers honest by keeping focus on criteria established and describe degrees of quality, proficiency, or understanding along a continuum. These rubrics are specifically designed to help teachers in objectively assessing performance tasks assigned to students. Hence, the use of authentic assessment in mathematics classrooms addresses the question, **"What performance criteria will I use to judge student work?"**. Rubrics should be carefully constructed since it determines whether the expectations set beforehand were achieved or not.

Theoretical Framework

Theoretically, this paper is anchored on Sternberg's theory of intelligence and Instructional Systems Design approach. Sternberg's triarchic theory of intelligence (1985) proposes that there are three basic forms of intelligence: analytical, creative, and practical. Analytical intelligence (componential) involves the ability to analyze, evaluate, judge, or compare and contrast; creative intelligence (experiential) involves the ability to cope with novel tasks; and practical (contextual) involves the ability to deal with daily tasks and problems (Sternberg, 2005). Sternberg's theory of intelligence entails the formulation of coherent and meaningful set of goals, and the identification of the competencies needed to reach these goals. Instructional Systems Design approach refers to the systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources, and evaluation (Smith & Ragan, 2005). Moreover, ISD approach is considered to offer opportunities to support the design of learning tasks for complex cognitive skills, and for the sequencing of these tasks throughout the curricula (Hoogveld, Paas, & Jochems, 2003). Using the ISD approach creates learning environments focusing more on learners by providing experiences allowing them to explore and develop their own potentials as in a constructivist frame of reference. Similar with Sternberg's theory of intelligence, one important element of the ISD approach is the development of the focus on objectives. Since this paper is intended to address the dearth of curriculum materials in mathematics, these theories address the concern of constructivist teachers on the factors that must be considered in the formulation of relevant and significant goals and objectives and the design and development of authentic learning activities for students' enduring understanding. The forms of intelligence from Sternberg's theory and the stages involved in ISD approach shall serve as guiding principles in the preparation and development of the instructional materials consisting of learning experiences that will improve students' understanding of the concepts, skills and values which can be carried out even outside the classroom.

Research Paradigm

Anchored on the Instructional Systems Design approach, the conceptual framework of this paper is illustrated in Figure 1.

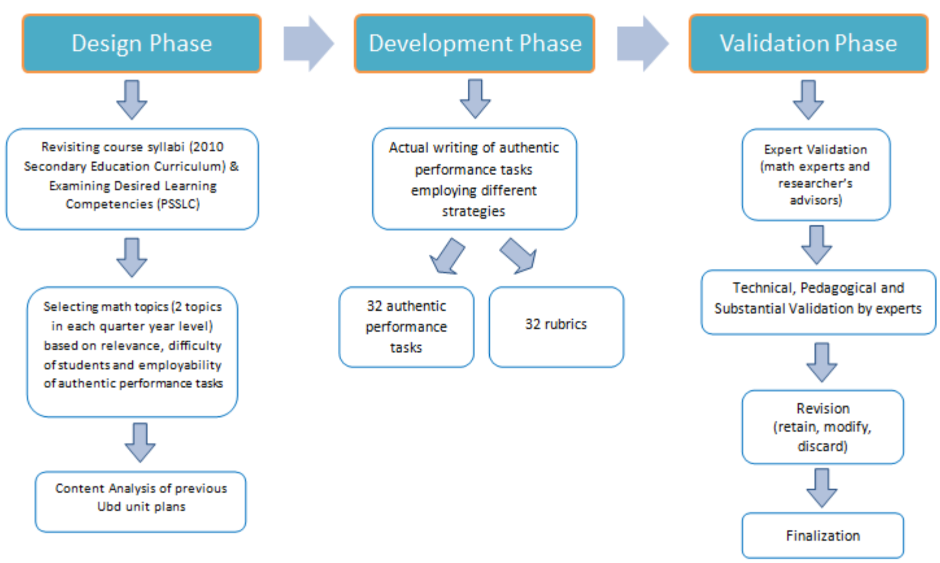

Figure 1
Schematic diagram of the procedure followed in the preparation of the materials

3. Methods

Research Design

This paper focuses on instructional materials development. It is descriptive in the sense that it describes how materials were developed and validated. It consisted of three phases: Design phase referring to the planning segment of the learning package, Development phase referring to the actual construction of the learning package, and the Validation phase referring to content and construct validation by mathematics experts and research advisors, the revision and the mini try-out of the performance tasks. Descriptive phenomenology was used to reveal the merits of the learning package. As cited by Wojnar and Swanson (2007), Husserl defined phenomenology as the science of the essence of consciousness focused on defining the concept of intentionality and the meaning of lived experience from the first person point of view.

Phases of the Development and Validation of Materials

Design Phase

In the design phase, identification of the need for the materials comprises the first step. This phase involved the revisitation of the course syllabi in mathematics based on the recent 2010 Secondary Education Curriculum. A thorough examination of the desired learning competencies as defined in the updated Philippine Secondary Schools Learning Competencies (PSSLC) was also included in this phase.

Selection of topics to be covered in the learning package, with the help of the list of competencies, was also established in this phase. Selection of topics was based on the following criteria: first, the topics should be relevant to real life situations; second, students find difficulty in learning these topics, and the third, authentic learning tasks can be employed in teaching these topics. Relevance of the selected topics indicates that there should be a transfer of learning that can occur with the students when they go out of the classroom. The second criterion refers to the topics in which students find difficulty in learning. Lastly, the employability of authentic learning tasks for the topics pertains that the tasks are appropriate and may possibly be conducted inside the classroom. Two topics in every quarter per year level were selected by the researcher to be covered in the learning package. Hence, there were 32 selected math topics to be included in the package.

After the selection of math topics to be covered, content analysis of previous UbD unit plans (Stage 2) on the selected topics was conducted by the researcher. The researcher was able to thoroughly analyze the contents of each unit plan as to whether or not these contents adhere to the established goals. The researcher studied the parts of the unit plans particularly the authentic performance tasks, to determine whether the math concepts behind each task are relevant to real world applications, and employ the constructivist approach to learning. Moreover, the rubrics, which will evaluate each performance task, were also carefully examined whether they were structured in a systematic way and were constructed in parallel with each task.

Development Phase

The development phase covers the actual writing of the instructional materials consisting of thirty-two (32) performance tasks. The researcher developed performance tasks using various strategies. Some constructivist strategies that were used included inquiry and discovery strategies (Flick, & Dickinson, 1997; Singer, & Moscovici, 2008), modeling (Jonassen, 1994) and scaffolding (Jonassen, 1994; Kaste, 2004), problem solving (Weeks, Mosely, & Torrance, 2001) and the like.

The authentic performance tasks required students to produce outputs which served as evidences of their understanding. Some of these performance tasks included mathematical modeling, storybook making, role playing, interviewing, designing, composing a song, reflective and poetry, writing, problem solving, etc. Through these authentic tasks, students were able to demonstrate the desired learning, conceptual understandings, skill and content acquisition. From the math topics selected in the design phase, 2 in every quarter per year level, the researcher developed 32 authentic performance tasks.

Also included in this phase was the construction of the rubrics which served as tools for assessing students' works. These rubrics were analytic in nature for purposes of assessing students' authentic performance tasks based on specified criteria and different degrees of quality of the students' outputs. These rubrics assessed the mathematical concepts, work ethics, creativity, and other criteria that would indicate the over-all quality of the tasks. Kist (2001) emphasized the importance of developing a rubric in every assessment as it specifically identifies and ranks criteria for assessing student performance, helps remove much of the guesswork in grading student products, formalize the process of evaluation by explicitly stating the criteria to be used for grading, keep teachers honest by keeping focused on criteria established and describe degrees of quality, proficiency, or understanding along a continuum. A rubric was constructed for each authentic performance task; hence there were 32 analytic rubrics used for assessing students' outputs. Each of the materials developed consisted of the following parts: year level, quarter of the school year, unit lesson in math, performance task and the rubric.

Validation Phase

The validation phase of this paper was divided into two parts: Expert validation and mini try-out of the performance tasks.

Expert validation

The learning package was presented to experts for content validation. Content experts, specifically mathematics teachers from 3 secondary schools in Metro Manila (St. Mary's High School, Immaculate Conception Academy-Greenhills, and PAREF Southridge School), evaluated the substantial, pedagogical and technical aspects of the proposed learning package. These schools were chosen on the basis of the following: formally and actively implementing the Understanding by Design (Ubd) framework since 2010; and PAASCU (Philippine Accrediting Association of Schools, Colleges and University) accredited having Levels II-III status. Content experts were the subject coordinators of the department who had at least 7 years of teaching and have adequate and up-to-date training on the use of Understanding by Design (UbD) framework. They evaluated the proposed materials using the Constructivist-Oriented Learning Package Evaluation Form. Based on the evaluation, comments and recommendations given by these math teachers who are experts in content and pedagogy, some parts of the package were retained, modified and discarded. The researcher's advisors were also consulted for further comments and suggestions in the improvement, revision and approval of the materials, respectively.

Mini try-out of the performance tasks

Five performance tasks were carefully selected by the researcher's advisors and were implemented in math classes in the laboratory high school of the University of Santo Tomas. With the permission from the office of the principal and in coordination with the mathematics supervising teacher, first to fourth year high school classes carried out the performance tasks. Said implementation was followed by an in-depth interview with the teachers. Some of these questions asked included: *What do you think of the performance tasks (PeTa)? What are the pluses? What* *learning problems can these performance tasks address? What were your difficulties in implementing these performance tasks? Which aspect/s in the proposed PeTa need further improvement?*

Responses to these questions were recorded, transcribed and analyzed. Verbalizations were transformed into field texts (Clandinnin & Connelly, 2000) and were processed through the cutting and sorting technique (Ryan & Bernard, 2003). The resulting statements were then phenomenologically reduced through the repertory grid, where both cool and warm analyses were conducted. The cool analysis consisted of the culling of significant statements of each respondent; these were later subjected to warm analysis in which data categories were formulated and themes emerged (de Guzman, et. al, 2011). Member-checking procedure was then utilized to ensure overall trustworthiness of the reported data (de Guzman & Guillermo, 2007).

4. Results

Design and Development Phases

This segment of the paper highlights the thirty-two (32) performance tasks and thirty-two (32) rubrics in secondary mathematics that were developed and were subjected to content validation by math experts.

Validation Phase

As part of the validation phase of this materials preparation, in-depth interview was conducted by the researcher with the teachers who implemented the performance tasks in their classes. The use of cool (sorting and categorization) and warm analyses (thematization) facilitated the process in interpreting their shared views on the merits of the proposed learning package. Interestingly, three significant themes emerged from the articulations and sharings of the teacher respondents. On the whole, merits of the implemented learning package lie on its applicability, communicability and equitability (ACE).

Applicability

In this study, it is interesting to note how the teachers shared their views of how the learning package helped their students to appreciate mathematical concepts, processes and relationships. As expressed by the teachers: *"By means of this performance task (PeTa), students were able to correctly convert logarithmic into exponential functions and at the same time appreciate the use of these concepts in one of the significant issues in our country, population growth rate." "Their interest and enthusiasm were exemplified by the students when they performed the task." "The PeTa did promote better understanding through the use of real-life scenarios and objects; they were able to translate the applications of the lessons in their outputs." "By means of this PeTa, they (students) were able to see the application of the concepts in daily living."*

When asked about the kind of performance task to be employed inside the class, the teachers emphasized its relevance with the particular lesson. As verbalized by one teacher respondent, *"One should consider the abilities of his/her students and see to it that the PeTa is relevant to the topic."* Similarly, another teacher commented, "*The PeTa being implemented should relate to the topic being discussed."* Another teacher said, "*One has to know if the PeTa would really fit to his lesson and if the students can comply with the requirements."*

As the foregoing verbalizations of the teachers suggest, the implemented performance tasks have the ability to elicit better conceptual understanding and appreciation of mathematical concepts, processes and relationships among the students.

Communicability

In this study, the interviewees pointed out that integrating the different forms of arts in mathematics classrooms creates a kind of environment for students to exhibit their creativity. Captivatingly, they said that besides mathematical skills, students who do not perform well in their written examinations were able to perform tasks and take this opportunity to excel in a different manner. As some teachers vividly responded, *"With the use of PeTa, students were able to show their creativity." "Their outputs were well thought of and were accomplished artistically." "Paper-and-pencil assessment is not enough to measure students' understanding." "Those students who got low scores on their exams exerted more effort in performing the PeTa." "Written assessment like quizzes, seat works, assignment, mastery and quarterly exams are not only the indicators of students' understanding. This PeTa provided an avenue where students were able to demonstrate their understanding."*

It is also worth mentioning that these teachers repeatedly expressed that the performance tasks promoted valuable interactions between and among the students. They believed that unlike the traditional pen-and-paper activities which are often done individually, the use of performance tasks inside the classroom requires interactions hence signifying various relationships with others. Articulated by the teachers, *"Values integration such as cooperation and teamwork were manifested by the students when they performed the task." "Students enjoyed very much because they got the chance to spend more time with their classmates while accomplishing the task." "They are motivated to finish the task since they knew that they will be working with their classmates."* Hence, as suggested by these teachers, *"It would be better to have more members in each group so that the PeTa can beconceptualized with more minds making it better and more presentable." "In terms of the number of students working on the PeTa, it is more preferred to have it by group instead of individual work."*

Interestingly, not only did students' artistry and interaction were significantly recognized by these teachers but also students' enjoyment in performing these tasks. As evidenced by the following verbalizations: *"Implementing the PeTa made my math class fun and interesting." "Performance-based activities are enjoyable." "Students enjoyed very much their PeTa."*

Taken as a whole, the *communicability* feature of the performance tasks refers to the provision of meaningful opportunities for students' greater interaction with their classmates, showcasing their creativity while having fun.

Equitability

In this study, when the teachers were asked about the rubric, it is evident how they strongly made remarks on its importance in the successful implementation of the performance tasks. Notably, they articulated that this form of assessment provides teachers with unbiased judgment in grading students' work. As teachers commented, *"The rubric made it more convenient for us teachers to assess students' output fairly." "The indicators under each weight for every anchor made the assessment more objective thus reducing biased judgment of student tasks." "The differences between and among the indicators under each weight are well constructed and easy to distinguish making it easier to evaluate whether students' work completely or incompletely met these indicators."* Brought about by the significant and crucial role that rubrics take in students' assessment, one teacher recommended, *"You may add more criteria or anchors."* Another teacher added, *"You can lower the weight of each anchor in the rubric."*

The use of rubrics to promote objectivity or fairness in students' assessment is labeled in this study as equitability.

5. Discussion

Using descriptive phenomenology, it is interesting to note that by and large, merits of the implemented learning package lie on its applicability, communicability and equitability (ACE).

Applicability

Findings of this study identified applicability as the ability of the performance tasks to elicit appreciation or meaningful learning and relevance of the mathematical concepts on the part of the students. As extensively explained by Reeves, Herrington and Oliver (2002), they listed that authentic activities should have real-world relevance. These tasks should nearly match scenarios which are present in reality. Similarly, these experiences require learning contexts to be real and purposeful, motivational, and practical in terms of the classroom environment in which learning takes place (Jobling & Moni, 2004). Moreover, since these tasks are real world activities which apply directly to a student's experience (Finch & Jefferson, 2012), these become meaningful to students and therefore, more motivating and deeply processed (Herod, 2002). Students who are immersed with authentic tasks can gain deeper sense of appreciation of mathematics by relating concepts, principles and theories with other contexts, scenarios and disciplines. The same way taken by Qing and Hong (2010), experiences which are task-based provide learning that is transferable from the initial context of the task, which is the focus for the learning, to another context. Lombardi (2007) reaffirmed that this kind of learning (authentic) intentionally goes beyond content and brings into play multiple disciplines, perspectives, ways of working, habits of mind, and communities. Undeniably, the function of authentic tasks is to show students relevance and stimulate them to develop competencies that are relevant for their future professional or daily lives (Gulikers, Bastiaens, & Martens, 2005).

Communicability

As shown in this study, communicability refers to the ability of the performance tasks to provide settings where students can interact with their classmates, exhibit their creativity, and experience enjoyment. The use of authentic tasks is derived from social constructivist principles (Woo, Herrington, Agonstinho, Reeves, 2007), in which the constructivist process works best in social settings as students have the opportunity to compare and share their ideas with others (Cooperstein & Kocevar-Weidinger, 2004). They added that although social interaction is frequently accomplished in small group activities, discussions within the entire class provide students the opportunity to vocalize their knowledge and to learn from others. Moreover, this finding appears to support Bruffy's (2012) study on participatory action research wherein he concluded that social interaction among students was greater when they were engaged in the authentic tasks. Significantly, not only is social interaction essential for knowledge construction, but it also allows students to verify their understanding (Vygotsky, 1978). In the same way as interaction, the use of authentic tasks demonstrates and enhances creativity. This is further strengthened by Cheng (2011) who listed role playing, drama, music, pictures, poems and stories as learning activities that can generate and enhance creativity among students. Likewise, Kind and Kind (2007), for their part, included open inquiry, problem solving, writing, metaphor and analogy as different approaches to promote creativity. The term creativity used in this study refers to the articulation of students' skills and talents to produce original and meaningful outcomes. Similarly defined by other researchers, creativity is the emergence of something novel from an individual or group (Swayer, 2006) that involves convergent and divergent thinking to ensure appropriateness (Dineen, Samuel & Livesey , 2005) and requires skills to generate these new ideas and possibilities (Daud, Omar, Turiman & Kamisah Osman, 2012). These kinds of learning activities are provided to students in constructivist classrooms. Hence, educational institution is the most important place to nourish the creative talents and abilities of students (Daud, Omar, Turiman & Kamisah Osman, 2012). Further, the aspect of enjoyment cannot be overlooked in implementing the performance tasks. The term enjoyment in this study refers to the expression of students' emotional experiences of motivation, willingness and satisfaction in performing the authentic tasks. The same way as other researchers synthesized enjoyment as engagement, positive affect and fulfillment in doing an activity (Lin, Fernandez & Gregor, 2012; Lin, Gregor, & Ewing, 2008). According to Cooperstein and Kocevar-Weidinger (2004), the class is much livelier and more productive and sessions seem less formal in a constructivist approach to learning. Further, they also observed that students are engaged, enthusiastic, productive, and motivated during class, frequently leave class with a feeling of accomplishment and confidence. Without any doubt, authentic tasks provided in constructivist classrooms promote enjoyment to students.

Equitability

Further, findings of the study have identified equitability as the ability of the rubrics to establish fairness in assessing students' performance tasks. This finding can be supported in the study made by Shipman, Roa, Hooten and Wang (2012), where they clearly stated that rubrics are touted as a fair, equitable, and consistent scoring guide measuring student achievement. Rubrics developed in this study are analytic in nature which includes concise performance criteria, rating scale, and descriptions of the expected performance at each level (Montgomery, 2000) beneficial in objectively evaluating all domains of learning preventing educators from making bias judgments (Gantt, 2010). Similarly, Isaacson and Stacy (2009) articulated that rubrics serve as a blueprint for grading; therefore there is less subjectivity in the interpretation of the level of performance and grade achieved. These rubrics create a standardized method (Shipman et. al, 2012) hence making grading practices more equitable (Knight, Allen, Tracy, 2010). Clearly, rubrics are tools consisting of indicators and criteria in assessing objectively the performance tasks made by the students.

6. Conclusion

This study aims to address the increasing demand for curriculum materials in the recently implemented framework in secondary mathematics. Specifically, the researcher developed and validated a prototype learning package in secondary mathematics. This learning package consists of authentic learning tasks, also known as performance tasks (PeTa), and the rubrics as assessment tools for these learning experiences.

In the light of the findings of this materials preparation endeavor, implementing performance tasks in mathematics classrooms can engage students in their transfer of deep and lifelong learning. The learning activities and experiences included in the package are mathematical modeling, storybook making, role playing, interviewing, designing (artwork, product, game), composing a song, reflective writing, problem solving, poetry writing, surveying, photography, urban planning, panel discussion, tour guiding, floor planning and comic strip writing. These tasks can be employed with the lessons in mathematics such as measurement, polygons, solid figures, angles, lines, relations and functions, variations, sequences, probability, statistics, counting techniques, equations, inequalities, systems of equations, fractions, special products, integers, logarithmic and exponential functions, plane coordinate system, and graphs of trigonometric functions, which are also included in this package. These lessons consist of concepts and constructs which are essential for students to learn that have value beyond the classroom.

This study also emphasizes on the role of the arts as vital tools for the success of mathematical learning. The different forms of arts incorporated in the performance tasks included in this package are poetry, music, movement, photography, visual arts, drama, etc. Moreover, this study reveals the importance of rubrics in assessing students' works objectively. These rubrics consist of performance criteria to be evaluated depending on the achievement levels met. Some of the criteria included in the rubrics in this learning package are the mathematical concepts, accuracy, validity, content, artistry, creativity, presentation (voice projection, facial expression, and gestures), teamwork, mechanics, unity and organization, originality, coherence, mastery, sources, appropriateness, relevance, punctuality, audience impact, and work ethics.

This study however was confined to the development and validation of a learning package particularly in secondary mathematics. Only selected lessons in mathematics were employed with performance tasks and only a few were chosen to be tried out in actual classes in a laboratory school.

Interestingly, the constructivist-oriented learning package developed in this paper can help address the complexities brought about by the current curricular reforms in mathematics education in the country. By and large, findings of this paper highly suggest the need to implement authentic tasks in mathematics classrooms. Continued work on the questions addressed in this paper may prompt teachers to develop materials in other subject areas and disciplines as well; and validate by focusing on the responses and insights of the students. Integrated with other theories of learning, future researchers can design and develop their own constructivist-oriented materials based on the needs and concerns of today's mathematics students.

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