Game Development as Students' Engagement Project in High School Mathematics

Ryan V. Dio (Ph.D.)
Sorsogon State College, Sorsogon City, Philippines
dio.ryan11@gmail.com

Asia Pacific Journal of Multidisciplinary Research
Vol. 3 No.5, 110-119
December 2015 Part I
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com

Date Received: November 11, 2015; Date Revised: December13, 2015

Abstract - *The general expectancies of the enhanced basic education curriculum in the Philippines focuses on the performance standards which can be expressed when students are able to produce products as evidence that they can transfer or use their learning in real-life situations. One way to assess students achievement is through an engaging activities that would require them apply the knowledge and skills acquired in the subject as the outcome of their learning. This descriptive method of research employed content analysis procedures and survey in describing and assessing the significant feature of the mathematical games as potential learning devices developed by the high school students through an engaging task assignment. It utilized purposive sampling techniques in the selection of the respondents and the submitted write-ups of mathematical games for analysis as typical sample in this study. The study revealed that the high school students developed mathematical board games with different objectives and mechanics as inspired by their learning, experiences, hobbies, and interest. Mathematical concepts and processes along numbers and number sense, measurements, algebra, geometry, and probability and statistics were integrated in the game through question card and mechanics of the game itself. The groups of students and teachers have high level of agreement as to the workmanship and usability, mechanics and organization, relevance to instruction/learning, and fun and enjoyment of the game as revealed by their assessment from very satisfactory to excellent level. Results implied that teachers in any subject area may use students' engagement project as teaching strategy to produce products and performance that would provide evidence of students' learning. The school curriculum makers may consider the students' output as subjects of research for further improvements, exhibits, and classroom utilization.*

Key words: *Mathematics, Game, Development, Students' engagement project, high school, Descriptive, Sorsogon*

INTRODUCTION

The world today requires better foundations for technological growth through globally competitive human capital as a product of quality education. Graduates of the present time and the next must be armed with appropriate knowledge, skills and attitude needed in building better society. The school as the instrument of the state trained and made every learner to be able and ready in the field of work which is the true combat zone.

Some of the required skills needed in the field of work are acquired and developed in Mathematics. As universally accepted core subject in the school, it teaches the student how to reason logically and helps them develop skills that they can carry into other disciplines and many situations in real life. In a practical sense, mathematics skills and understanding is one of the important bases in determining the future success of today's young people.

Quality education can truly be achieved if there are teachers who ensure quality time, never cease to innovate and discover. Students show different skills and performance in Mathematics, most of them would rather memorize than search for deeper meaning of concepts which is commonly observed in secondary schools. One of the major concerns of the numerous researches of mathematics educators is on how to enhance students' skills in problem solving which is an integral part of a bigger area of critical thinking, a generally acknowledge goal of education. Critical thinking and problem solving skills as the twin goal of mathematics curriculum in the Philippines[1] can be achieved through well planned learning activities such as projects and home works with the integration of appropriate mathematical tools which include manipulative objects, measuring devices, and ICT .

Garcia [2] concludes that homework if prepared and planned by teacher can enhance students' learning in mathematics. Mathematics homework should be prepared for a particular intent or combination of intents geared to students' needs, learning styles and achievement levels. It should show wide variety of challenging tasks of varying length, frequency, and level of cognitive domain it aims to address. There is a

widespread belief that homework builds character, work habits, and academic skills. Homework for instructional purposes is assigned to help students practice what they did in class, prepare for new lessons, extend what they have learned, or integrate separately learned skills by applying them on projects. While doing homework, students develop time-management and work skills, develop positive discipline, and students learn to work at their own pace. The ultimate desire of home work is to have a positive effect on students' achievement.

On the other hand, de Frondeville [3] defines project-based learning as a dynamic approach in which students actively explore real-world problems and challenges and acquire a deeper knowledge. He believed that managing high-quality project-learning environments are productive in any classrooms, whether project learning is a central part of the curriculum or not. The cited ideas give insights to the present endeavor that game development as student engagement project is a worthwhile learning activity that could be done inside the mathematics classroom situations.

Killen [4] in his paper posits that teaching is only teaching if learners learn. One way to assess students achievement is through an engaging activities that would require them apply the knowledge and skills acquired in the subject as the outcome of their learning. Outcomes based-education (OBE) assumes that students learn important things when they use their knowledge and skills in relevant contexts and in ways that require them apply what they know and to extend their thinking. OBE as learner centered education starts with a clear specification of what students are to know, what they are to be able to do, and what attitude or values are desirable by the end of the programme. Game development as student engagement project in mathematics classroom would require student transforms the knowledge and skills learned in the subject into a concrete product that can be disseminated and utilized for adoption of the education community as their contribution and outcome of their learning.

In his article Cruz [5] stresses that the simple way to describe K to 12 curriculum is it is outcomes-based. Students from Kindergarten to Grade 12 are being prepared for one or more of the following outcomes: higher education, middle level skills development, entrepreneurships, and employment. Teachers being the front liner of the education system play a vital role in the achievement of this goal by designing engaging student activities/projects and using various assessment strategies.

The general expectancies of the enhanced basic education curriculum in the Philippines are express in specific terms in the form of content and performance standards. The performance standards can be expressed when students are able to produce products as evidence that they can transfer or use their learning in real-life situations. Thus, learning time can be extended to include off-school learning experiences at home or in the community for transfer of learning to real-life situations. The outputs of such off-school learning experiences are usually in the form of products and performances which shall be monitored and credited accordingly [6].

The Sorsogon State College (SSC) as the primary higher education in Sorsogon Province is maintaining the Teacher Education Program Laboratory High School (LHS)that is proactive to the changing demands of the basic education sector and its stakeholders in accordance with section 4 of RA 7666 [7]. It is imperative that the Laboratory High School of the college must be in adherence to any changes and innovations at the basic education sector governed by the department of education so that its teacher education program is always updated into it. Thus, each faculty should always be given chance to explore teaching learning situations by taking considerations DepEd issuances that would address students' needs.

The researcher as faculty of the teacher education program handling high school students of the college explored the possibilities of giving student task through an engaging project activity that would cater students' creativity and be able to apply and integrate knowledge and skills acquired in the mathematics classroom. It started with setting goal to be achieved which requires clear instructions as prerequisite to the project activity which is the development of mathematical games. Students are given chance to group themselves with at most five members and decide what kind of game they wanted to develop with an integration of the knowledge and skills acquired in mathematics. They were tasked to show evidence that such games involves aspects of mathematics such as computational underpinnings played by two or more individual or teams whose rules, strategies, and outcomes is defined by clear mathematical parameters. Their outputs shall possess good workmanship, mechanics and organization which are

relevant to classroom instructions and learning while having fun and enjoyment.

Numerous studies have been conducted on the positive effect of games when integrated in classroom teaching particularly in mathematics class. Teachers should start creating a wholesome atmosphere in the mathematics classroom to better appreciate the subject. Given the chance to work with their group mates in planning, searching, exploring, critiquing, and creating is an innovative engaging task for the high school students towards the achievement of the set challenging goal. It requires careful planning on the part of the teacher so that he can lead the students properly to produce intended products as an output of the activity that would result to a tangible outcome of educational objectives assuring student learning.

Quan and Tan [8] introduce a game in motivating students to do creative mathematics. A particular application of fundamental principles of counting that uses the entries in Pascal's Triangle was integrated in the game. In doing so, some essential properties of the Pascal's Triangle are noted. The study involves a familiar game which appeared in a TV show called PLINKO and how its outcome can be analyzed using properties of the Pascal's Triangle through observation of paths in the game which lead to a generalization and introducing the concept of "deficit paths" on the Plinko game board.

The experimental study of Villarosa and Juacalla [9] on the effects of Trigo Wheel on students' learning in Trigonometry revealed that students' scores from pre-test to post-test increased from needs improvement to satisfactory. Trigo wheel is a device created from cheap materials featuring some important topics in trigonometry for fourth year high school level such as coordinates on the unit circle, sine and cosine value, conversion of degree measures to radian and vice versa among others. It was concluded that this help students understand the mentioned lessons and improved their confidence and performance in the subject.

Moreover, the study of Schlosser and Balzano [10] utilized twenty experienced, urban teachers volunteered to attend monthly professional development workshops where they engaged in math games, simulations, and problem-solving activities based on the Common Core and modeled by college faculty. It was revealed in the study that majority of teachers who participated in game-based learning at the professional development workshops believed that their own math knowledge and skills improved. They also reported that the use of games and activities in their math clubs increased students' understanding and enjoyment of math, as well as their ability to focus and stay engaged even when activities were hard for them. Play experiences motivated young adolescents to think mathematically were central to their evolving beliefs about effective teaching strategies.

The aforementioned studies suggest that students learned best if they are actively involved in the teaching-learning process through concrete and well planned activities made by the teacher. These assumption can be supported by experiential learning theory of Kolb which emphasizes on how experiences, including cognition, environmental factors, and emotions, influence the learning theory and prepares the learner to the world of work. This could be strengthened by the constructivism theory of Bruner which illustrates that learning is an active process in which learner creates new ideas based from their current and past knowledge. Constructivists believe that learning should be based on activities and problem that students might encounter in the real world.

Bruner's theory was expounded by McLeod [11] in his site that important outcomes of learning include not just the concepts, categories, and problem-solving procedures invented previously by the culture, but also the ability to invent these things for oneself. Another site of him mentions Vygotsky's theory [12] which stresses the fundamental role of social interaction with a skillful tutor in the development of cognition towards higher mental functions. Teachers' play a significant role in scaffolding where they collaborate with students in practicing the four key skills: summarizing, questioning, clarifying, and predicting.

The present study also feed into current interest in collaborative and cooperative learning strategy, suggesting that each member of small groups should work together in accomplishing a common task through sharing of ideas and expertise. The ownership of teaching and learning which include setting goals, assessing learning, and facilitating learning is shared by groups of students, and is no longer the sole responsibility of the teacher. Students have more opportunities to actively participate in their learning, question and challenge each other, share and discuss their ideas, and internalize their learning which helps

them engage in thoughtful discourse and examine different perspective [13].

These could be done through authentic tasks such as project-based learning. David [14] elaborates the core idea of project-based learning is that real-world problems capture students' interest and provoke serious thinking as the students acquire and apply new knowledge in a problem-solving context. The teacher plays the role of facilitator, working with students to frame worthwhile questions, structuring meaningful tasks, coaching both knowledge development and social skills, and carefully assessing what students have learned from the experience. Advocates assert that project-based learning helps prepare students for critical thinking and collaboration skills required in the workplace. Students' work project output reveals their learning that could be exhibited as Weyers and Dole [15] have done in the edutopia website.

This classroom activity is in consonance to DepEd order 73, series 2012 [16] in its directive that assessment process should be holistic, with emphasis on the formative or developmental purpose of quality assuring student learning. The highest level of such focuses on the products or performances which students are expected to produce through authentic performance tasks. Products or performances should be reflective and evidence of what we want students to be able to do with their learning. The memorandum emphasizes that schools are encouraged to put up exhibits of student products across subjects as culminating activity. Thus, when parents receive the report card and confer with teachers they will actually be witnessing what students are learning in school.

One of the outputs of this students' engaging project activity in the Laboratory High School has been sent for competitions in the division level and able to bag an award for two consecutive school years. In the competitions held last school year 2014-2015, the Laboratory High School represent the Sorsogon City Division in the Regional level for the mathematical games. It is in this sense, this study has been conducted to describe and assess students' output, learning, and engagement through content analysis of their write-up submitted that would give bases for integration of these outputs in the mathematics classroom teaching at different level.

OBJECTIVES

The main purpose of the study is to describe and assess the mathematical games developed by the high school students as potential teaching device in enhancing students understanding of the mathematical concepts and processes. The following are the specific objectives of this study: to describe the mathematical games developed by the students; to determine the common mathematical concepts and processes integrated in the game; and to assess the characteristics of the mathematical games as perceived by both the students and teachers.

MATERIALS AND METHODS

The qualitative nature of this descriptive method of research is through the use of content analysis. Fraenkel and Wallen [17] define content analysis as a research technique that enables researchers to study human behavior and obtain descriptive information of one kind or another in an indirect way by analyzing communications. It is just what its name implies: the analysis of usually, but not necessarily, written contents of communication. Content analysis was employed in describing and analyzing the write-up of the games developed by the group of SSC Laboratory High School students. On the other hand, to assess the general characteristics of the games survey and informal interview was conducted.

This study utilized purposive sampling techniques in the selection of the respondents and the group projects as subject of the discussion of the study. The eight submitted write-ups of SSC-LHS students for the mathematical game developed been organized, compiled, and used as the typical sample in this study. The board games developed by Section "A" fourth year high school graduating students have been selected based on the criteria that these should possess characters of mathematics and could be utilized as a potential teaching device in enhancing students' understanding of mathematical concepts and processes in different grade level.

In consonance with the directive of DepEd order 73, series 2012 [16] on the highest form of assessing students learning focusing on the products or performances which students are expected to produce through authentic performance tasks, the researcher as a classroom teacher handling mathematics class in high school arrived to an idea to let the students produce such kind of product. This should be reflective and evidence of what the fourth year HS students can do with their acquired learning in mathematics classrooms. This view could be supported by the revised Bloom's taxonomy of

cognitive domain with creating as the highest form of objectives.

The classroom mathematics activities started with the orientation to the IVA Excellence students of the LHS of the requirements to be submitted at the end of the grading periods. One of which is the special project featuring the development of mathematical game to be made by group of at most five members. The game should feature mathematical concepts and processes they have learned from schooling as fourth year high school students. During the orientation, the different stages of game development including the format of the paper write-up has been enumerated, discussed and clarified. Students were given freedom what kind of mathematical games they want to developed and what mathematical concepts and processes to integrate.

Each group conducted their own hands-on investigation activities such as group discussion, library and internet research, and simulation activity that lead them to conceptualization of the project for one grading period. At the end of the first grading period, each group submitted their initial project for comments, suggestions, and improvements. Their outputs have been sent to exhibit during the Math Days conducted by the Number Evaluators Club (NEC) of the college on September 2014 for them to have a chance to let the students at different level play the game and able to explain the rules and mechanics of the game. Each group was able to distribute questionnaire checklist to at least 10 students who play the game during the exhibit to evaluate its general characteristics.

Towards the end of the second grading period, five faculty members composed of three mathematics instructors, one science instructor, and one language instructor of LHS were asked to evaluate the developed game. Following the comments and suggestions, the students were able to improve their project using the criteria: workmanship/physical appearance (20%), mechanics and organization (20%), relevance to instructions/learning (30%), and fun and enjoyment (20%), economy (10%). These criteria have been the bases for the selection of the best project to represent the SSC-LHS for the inter-school contest. The project chosen for competition was subjected to more refinements, improvements, and proofreading of the write-up.

The submitted write-up of the students has been subjected to thorough review and analysis of the researcher to describe the feature of game and determine the common mathematical concepts and processes integrated by the fourth year students which reflects their learning and understanding. Frequency count, weighted mean, ranking, and spearman's rank-order correlation coefficient were the statistical tools used in the evaluation of the games characteristics.

RESULTS AND DISCUSSION

Mathematical Games Developed by the Students

Table 1 shows the different mathematical games developed by the high school students which are 6 to 1, Matholopogy race, Mickey Mouse Math House, The Functional Race, Math is the Way, The Math Wizard's Game, Track n' Field Trip, and Kaname. These board games reflect the mathematics concepts in their name except for the last two mentioned games. Six of them require a maximum of 4 solo players to start a game while the *Mathopology race* requires a maximum of 4 pairs and the *Math Wizard's game* requires a maximum of 2 teams of 7 players each to start a game.

Table 1. Mathematical Games Developed by the High School Students

Mathematical Game	Player	Max No. of players	Requirements / Materials Needed
1. The 6 to 1 Game	Solo	4	Board game, Marbles, dice, set of math questions
2. Mathopology Race	Pair	8	Board game, dice, cars, set of math questions (easy, moderate, hard, extremely hard)
3. Mickey Mouse Math House	Solo	4	Board game, Mickey Mouse Cartoon Characters, stopwatch, dice, houses, set of math questions
4. The Functional Race	Solo	4	Race board, game piece, dice, set of math questions on functions
5. Math is the Way	Solo	4	Board game, dice, set of math questions
6. The Math Wizard's Game	Team	14	Board game, dice, tokens, set of math questions
7. Track n' Field Trip	Solo	4	Board game which contains spin wheel, question card
8. Kaname	Solo	4	Board game, dice, question card

The *6 to 1 game* utilizes board game consists of 89 holes divided into four groups, each group of holes consist the home and waiting shed holes. It is a game of chance, knowledge and patience in answering problem set in order to home all the 4 marbles in clockwise directions. It is named 6 to 1 because the key in winning the game is to get 6 or 1 in rolling the dice, they cannot move unless they get 6 or 1.

The board game *Mathopology Race* is patterned from the famous television and a worldwide phenomenon game show "The Amazing Race". The name of the game is basically derived from the words "*math"* and *"opology"*. *Math* means a group of related sciences which is concerned with the study of number, quantity, shape, land, space and their interrelationships by using a specialized notation while "*ology"* which is a compound suffix, it is a combination of *o* which means "of" and *logy* which means "study, science & theory". It could be also noted in its appearance the topological feature of the game wherein the players are racing to reach the final destination called pit stop using their knowledge and understanding through series of mathematical questions that's why it is called *Mathopology Race*. This utilizes the common terminologies of the amazing race such as express pass, yield, roadblock, and detour with the corresponding tasks and mathematical problems to be answered within the allotted time. The race is only good for an hour. If the race is still not completed after an hour, the team closest to the pit stop will be announced as the winner.

The *Mickey Mouse Math house* is a board game which utilizes four Mickey Mouse characters in the known TV cartoons show that represents the players. Aside from the four characters, this board game uses dice, coins, houses, and math problems. Each player shall have 10 coins each as starting money that they should keep and utilize to earn more houses and land when they are able to answer math challenge problems with corresponding points according to the level of difficulty.

The *Functional Race* and *Math is the Way* board games are patterned to the game snakes and ladders with 100 tiles in the board. They use varied game pieces and a single dice. Both games have their own modifications; the *Math is the Way* utilizes candy and ants as obstacles to moving forward or backward, respectively, aside from the math questions from very easy to hard questions towards candy factory which is the 100^{th} tile while the *Functional Race* utilizes different three groups of colored tiles, blue tiles will caused the player to solve equations or problems related to functions, red tiles will make lose progress, yellow tiles will cause to advance a couple steps, and the black tile located at the center of the board game is the finish tile.

The *Math Wizard's game* is played by wizards and witches sugar-coated with mathematics as their power. This game is patterned from the fictional competitive sport called Quidditch in the Wizarding World of the *Harry Potter* universe, featured in the series of novels and movies. Matches are played between two teams of seven players riding flying broomsticks, using four balls: a Quaffle, two Bludgers, and a Golden Snitch. The board game contains six ring-shaped goals situated atop poles of different heights, three on each side of the pitch. The game can be played by a minimum of 2 wizards each of which can control an entire team of seven which consists of 2 beaters, 3 chasers, 1 seeker, and 1 keeper. Chasers of the team try to catch the Quaffle and scored 10 points by shooting it through their opponent's Golden Hoops and answering a Mathematics-related question. The Seeker tries to win the game by finding the Golden Snitch and scored 150- points when he answered the corresponding math problem. The Beaters try to hit the other team's wizards with a bludger while the keeper tries to prevent the other team's chasers from scoring.

Track n' Field Trip is a math board game patterned to track n' field sports where running events is being held. In this game, the word "trip" refers to a tour by a chosen vehicle in some chosen places in the world such as Disneyland, Mt. Fuji, San Francisco, Paris, and etc. There are some corresponding instructions in each destination the player has to follow including spinning the wheel and solving math problems on the space that contained it. The first player to go back to its original position will be declared as winner.

Kaname is derived from the Bikol word "kanam" means *game* and "mi" means *ours*. The concept of the game was inspired from a survival challenge which is composed of three stages. The three stages represent the island of Luzon, Visayas, and Mindanao with corresponding intensity of difficulty of questions in the board game. The easy questions (Luzon) can be done mentally within 30 seconds, the average questions (Visayas) also done mentally for 45 seconds, and solving the questions at the difficult level (Mindanao) can be done with scratch paper for one minute. Each of the level of difficulty has its checkpoints, bridges, traps, and gates as obstacles with the corresponding task and/or problems the player has to perform before moving to the next level.

The aforementioned games reflect the creativity, learning, hobbies, and interests of the high school students. They create something according to the learning experiences in the school mathematics as inspired by their interests in any learning areas which are incorporated in their own inventions. This suggests that this activity is a proper and good venue for them to explore, express themselves, and work with others according to their common interests in other related areas such as sports, geography, movies, TV shows, among others.

Classroom activities such as this can lead to the attainment of the core idea David [14] on project-based learning as an authentic task given by teacher to the students. This where the real-world problems capture students' interests and provoke serious thinking as the student acquire and apply new knowledge in a problem-solving context. This could be strengthened by the constructivism theory of Bruner [11] which illustrates that

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com

learning is an active process in which learner creates new ideas based from their current and past knowledge. This become the focus at present in assessing the learning of students under the K to 12 curriculum [16] which is to produce products as evidence that they can transfer or use their learning in real-life situations.

Common Mathematical Concepts and Processes Integrated in the Game

The games developed by the high school students illustrate the integration of mathematical concepts and processes. It consists two ways of integrating the mathematical concepts; the integration in the set of questions, and the integration in the game mechanics as to how the game is played. It could be notice that the students considered algebra topics such as radicals, exponents, functions, linear equations, quadratic functions, polynomials, slope, sequences and logarithm in the set of question card with varying degree of integration in the game. All the developed games integrated algebra in the set of questions. This is because advance algebra was the focus of discussions in their mathematics class during the development of the game and another reason is that most of the students find difficulty in the study along this topic that is why they integrated them in the game as drill exercises during their vacant time.

There are group of student who find interests to incorporate other math topics in the game such as geometry, trigonometry, and statistics. An interesting part of this discussion is that the *Mathopology Race* group integrated math riddles in their game which is a good venue for enhancing the critical thinking and analysis as illustrated by the example below:

> *A word I know, six letters it contains. Subtract just one, and twelve is what remains.*

In situation like this, students could create stories and phrases incorporating the mathematical relationships and features in the statements. This generates imagination and provokes critical thinking skills of the students in the world of mathematics and other branch of study.

Moreover, the mathematical games integrated concepts of counting and probability in the mechanics of playing the game since all use dice as part of the procedures before moving towards the finish line. Without their intentions, they developed a game of chances from the time on how they started the game and how they play the game. Geometrical concepts have been integrated in the game in the sense that each board game features geometrical figures that lead to the players' familiarization of them. On the other hand, the *Mickey Mouse Math House* board game integrated Business Mathematics concepts in the game where players aimed at gaining more coins, lands, and houses. With the goal of winning the game, they should have the highest score or they should eliminate their opponents by acquiring all their coin and/or houses and declare them as bankrupt. This illustrates further to use wisely what you have acquired and gained by using your knowledge and skills in answering mathematical problems in the set of questions.

These results demonstrate the knowledge and skills acquired by the students in the study of mathematics while in high school level. It supports the idea of Killen [4] that teaching is only teaching if learners learn. He further express that one way to assess students achievement is through an engaging activities that would require them apply the knowledge and skills acquired in the subject as the outcome of their learning. Outcomes based-education (OBE) assumes that students learn important things when they use their knowledge and skills in relevant contexts and in ways that require them apply what they know and to extend their thinking.

Characteristics of the Mathematical Games as Perceived by the Students and Teachers

Table 2 reflects the assessment of the groups of students and teachers in terms of the workmanship and usability of the mathematical games identified.

Table 2. Workmanship and Usability of the game

Mathematical Game	Students			Teachers		
	WM	D	Rank	WM	D	Rank
1. The 6 to 1 Game	4.62	E	6	4.20	VS	5.5
2. Mathopology Race	4.93	E	1	4.40	VS	4
3.Mickey Mouse Math House	4.82	E	3	4.80	E	1.5
4. The Functional Race	4.44	VS	8	4.00	VS	7.5
5. Math is the Way	4.91	E	2	4.80	E	1.5
6. The Math Wizard's Game	4.67	E	5	4.20	E	5.5
7. Track n' Field Trip	4.47	VS	7	4.00	VS	7.5
8. Kaname	4.78	E	4	4.60	E	3

r_s = 0.84, significant p < 0.05; D- Description; E-Excellent; VS-Very Satisfactory

The two groups of respondents rated the games from 4.00 to 4.93 which fall under the description of very satisfactory to excellent level. The table shows that both group of respondents rated the workmanship and usability of *Mickey Mouse Math House*, *Math is the Way* and *Kaname* as excellent. The respondents perceived that these board game including the *Mathopology Race* are the top 4 in terms of workmanship and usability which met the required standards in terms of the artistic quality, easy to manipulate and can be used in a several teaching-learning situation for a longer period of time.

The computed correlation value of r_s which is 0.84 revealed the significant high positive relationship between the assessments of the two groups of respondents. This means that the respondents have high level of agreement in

their evaluations of the games along workmanship and usability as revealed by the results of the top 4 and below 4 rated games. Furthermore, both group of respondents agree that the *Functional Race* and the *Track n' Field Trip* board game have to improve its workmanship and usability because they are made of cardboard which can easily be destroyed.

Table 3. Mechanics and Organization of the Game

Mathematical Game	Students			Teachers		
	WM	D	Rank	WM	D	Rank
1. The 6 to 1 Game	4.60	E	7.5	4.00	VS	7.5
2. Mathopology Race	4.82	E	2	4.80	E	1.5
3. Mickey Mouse Math House	4.74	E	5.5	4.20	VS	5.5
4. The Functional Race	4.80	E	3.5	4.60	E	3
5. Math is the Way	4.90	E	1	4.80	E	1.5
6. The Math Wizard's Game	4.60	E	7.5	4.20	VS	5.5
7. Track n' Field Trip	4.74	E	5.5	4.40	VS	4
8. Kaname	4.78	E	3.5	4.00	VS	7.5

r_s = 0.73, significant p < 0.05; D- Description; E-Excellent; VS-Very Satisfactory

Table 3 shows the assessment of the two groups of respondents in terms of the mechanics and organization of the game. It can be gleaned from the table that both group of respondents rated mathematical game *Mathopology Race*, *Functional Race*, and *Math is the Way* from 4.60 to 4.90 which fall at excellent level. These top 3 board game along this criterion have clear, organized, easily understood by the players, and has systematic presentation of the mechanics on how they are played as perceived by the two groups of respondents. Generally, the students rated the board games as excellent while the teachers rated them as very satisfactory. The table also shows that the two groups of respondents have similar ranking as to which of them is highest and lowest in terms of the mechanics and organization. This result could be strengthened by the result of correlation value (r_s = 0.73, p< 0.05) which denotes high degree of agreement between the group of respondents' evaluation.

Table 4. Relevance of the Game to Instructions/Learning

Mathematical Game	Students			Teachers		
	WM	D	Rank	WM	D	Rank
1. The 6 to 1 Game	4.40	VS	8	4.00	VS	8
2. Mathopology Race	4.88	E	1	4.80	E	1.5
3. Mickey Mouse Math House	4.60	E	7	4.40	VS	5
4. The Functional Race	4.80	E	2.5	4.80	E	1.5
5. Math is the Way	4.77	E	4	4.60	E	3.5
6. The Math Wizard's Game	4.63	E	6	4.20	VS	6.5
7. Track n' Field Trip	4.73	E	5	4.20	VS	6.5
8. Kaname	4.80	E	2.5	4.60	E	3.5

r_s = 0.89, significant p < 0.05; D- Description; E-Excellent; VS-Very Satisfactory

Table 4 illustrates the relevance of the game to instructions/learning as assess by the students and teachers. Both the students and teachers perceived that the developed mathematical games such as *Mathopology Race*, *Functional Race*, *Math is the Way, and Kaname* are excellent along this area as illustrated by their mean rating from 4.60 to 4.88. The respondents agreed that these board games mentioned can give accurate and significant picture of math concept they represent and can stimulate thinking appropriate to the learner's ability, interest, and experience. This suggests that these games possess the characteristics that they could be utilized as supplementary tools or device in the teaching and learning of the topics integrated in the game which can be done during the lesson discussions or during the vacant time.

A computed correlation value of r_s = 0.89 of the ratings of the students and teachers is found to be significant (p < 0.05) which means that the two group of respondents consistently rated the games from the lowest to highest in rank along this area. The respondents have high level of agreement that the *Mathopology Race*, *the Functional Race, Math is the Way*, and *Kaname* are the top 4 board games in terms of its relevance to instructions/learning. These could be functionally utilized during the Independent cooperative Learning (ICL) period and/or vacant time as instructional devices that supplements in the learning of mathematics while having fun.

Table 5. Fun and Enjoyment of the Game

Mathematical Game	Students			Teachers		
	WM	D	Rank	WM	D	Rank
1. The 6 to 1 Game	4.54	E	8	4.20	VS	7
2. Mathopology Race	5.00	E	1	4.60	E	2
3. Mickey Mouse Math House	4.88	E	2	4.60	E	2
4. The Functional Race	4.76	E	4.5	4.20	VS	7
5. Math is the Way	4.80	E	3	4.40	VS	4.5
6. The Math Wizard's Game	4.76	E	4.5	4.40	VS	4.5
7. Track n' Field Trip	4.60	E	7	4.20	VS	7
8. Kaname	4.70	E	6	4.60	E	2

r_s= 0.69, Significant p < 0.05

Table 5 shows the assessment of the students and teachers in terms of fun and enjoyment that could be obtained from the game. It can be noted from the over-all rating of the students for each game ranges from 4.54 to 5.00 which fall at excellent level. This signifies that students enjoy so much each game. Their assessment on *Mathopology Race*, *Mickey Mouse Math House*, and *Kaname* board games is similar to the assessment of teachers which is at excellent level. Teachers' assessment on the other five games falls on the very satisfactory level which can be attributed only as to their perceptions since

they did not actually play the game while the students utilized the game during their leisure/vacant time which leads them to a better appreciation of the mechanics and objectives of the game.

The computed correlation value ($r_s = 0.69$, $p < 0.05$) is found to be significant which means that the students and teachers have agreement as to their assessment in terms of fun and enjoyment of the game. It signifies that the top 4 board games which can give enjoyment to any players are the *Mathopology Race*, *Mickey Mouse Math House*, *Math is the Way*, and the *Math Wizard's Game*. Data suggest that the developed board games possess the characteristics that can provide players relevant learning; improve mathematical skills, artistic ability and sportsmanship; and provide relaxations and enjoyment.

CONCLUSIONS AND RECOMMENDATION

In the light of the foregoing findings of this study, the following conclusions are drawn: (1.) the high school students developed mathematical board games with different objectives and mechanics as inspired by their learning, experiences, hobbies, and interest; (2.) students integrated mathematical concepts and processes such as numbers and number sense, algebra, geometry, probability and statistics through question card and mechanics of the game itself; (3.) the students and teachers rated the workmanship and usability, mechanics and organization, relevance to instruction/learning, and fun and enjoyment of the game from very satisfactory to excellent level; (4.) the students and teachers have high degree of agreement in their evaluations along the perceived characteristics of the game.

It is generally observed that students show different skills and performance in Mathematics. Teachers play a vital role in the delivery of quality instructions through well planned activities that would require application of acquired knowledge and skills, and would provoke critical thinking and problem solving skills among secondary school learners. One of which is the student engagement project through game development which requires student's willingness, desire and compulsion to participate and collaborate in, and be successful in the process of creating game incorporating their learning in high school mathematics. This provides concrete experience for the learners as expounded by the experiential learning theory of Kolb and constructivism theory of Bruner emphasizing on how teacher provision of students' experiences influence creation or construction of new knowledge and skills that would prepare them to the world of work. Teacher as facilitator of learning has a critical part in the planning stage in this kind of activity, this is where he set target or goal on what students should be able to do and what desirable attitude or values to be achieved based from what they have learned in the activity. As highlighted in the zone of proximal development theory of Vygotsky that students need the guidance and encouragement from a skilful individual in order to achieve the optimum and desirable result. A collaborative and cooperative undertakings between and among group of students should be emphasized while doing the project development where they develop time-management, work skills, and positive discipline as lifelong learning. When students are given a chance to work with others, they could explore and create products as a result of their learning and shared experiences according to their common interests and skills.

Cognizant to the outcomes-based education, teachers in any subject area may use students' engagement project as strategy to produce products and performance as evidence of learning. Mathematics teachers may integrate mathematical concepts and processes along students' context and interests in any area of study for better appreciation of the subject. The developed board games by the students may be further improved and validated and can be used as potential math devices for learning and instructions. Moreover, curriculum makers may consider the output of the students as subjects of research for further improvements, exhibits, and classroom utilization.

REFERENCES

[1] Department of Education (2011). K to 10 Curriculum Guide in Mathematics – Kindergarten to Grade 10.

[2] Garcia, Elino S. (2010). Enhancing mathematics learning through effective homework. Intersection Journal of Philippine Council of Mathematics Teacher educators (MATHED), Inc., Volume 11, p. 16- 25. ISSN 0118-6876

[3] de Frondeville, Tristan (2009). Ten steps to better student engagement, project-based learning. From http://www.edutopia.org/project-learning-teaching-strategies. (Retrieved Dec 26, 2014)

[4] Killen, Roy (2000). Outcomes-based education: Principles and possibilities. Unpublished manuscript, University of Newcastle, Faculty of Education. drjj.uitm.edu.my/DRJJ/CONFERENCE/UPSI/OBEKillen.pdf (Retrieved December 25, 2014)

[5] Cruz, Isagani (2013). K to 12 outcomes. The Philippine Star. http://www.philstar.com/education-and-home/2013/05/30/947914/k-12-outcomes (Retrieved December 25, 2014)

[6] Department of Education Order 31, series 2012. Policy guidelines on the implementation of Grade 1 to 10 of the K to 12 Basic Education Curriculum (BEC) effective SY 2012 – 2013.

[7] Sorsogon State College Laboratory High School Academic Manual. SSC BOT Resolution No. 59, series 2011.

[8] Quan, Reymond Anthony M. and Tan, Evelyn L. (2009). Excerpted from the 7th Biennial International Conference on Mathematics Education Proceedings, Philippine Council of Mathematics Teacher Education (MathTEd), Inc. Palawan State University, Palawan, October 23-24, 2009.

[9] Villarosa, Ramil D. and Juacalla, Merilyn P. (2014) The effects of Trigo Wheel on students' learning in Trigonometry. Excerpted from Book of Abstract on National Research Conference on "Sharing Knowledge Across Colleges and Universities". Quezon City: Research and Educational Development Training Institute (REDTI) ISSN 1656-166

[10] Schlosser, Linda K. and Balzano, Betsy (2014) Playing to learn: How After-school Clubs influence teachers' beliefs about instruction. SAGE Publication. http://sgo.sagepub.com/content/4/4/21582440145580 31.full (Retrieved December 13, 2014)

[11] McLeod, S. A. (2008). Bruner. Retrieved from http://www.simplypsychology.org/bruner.html

[12] McLeod, S. A. (2007). Lev Vygotsky. Retrieved from http://www.simplypsychology.org/vygotsky.html

[13] http://www. teachervision.com/pro-dev/cooperative-learning/48531.html. © 2000-2014 PearsonEducation, Inc. (Retrieved December 28, 2014)

[14] David, Jane L. (2008).What Research Says About … / Project-Based Learning. Association for Supervision and Curriculum Development Volume 65, No 5. From: http://www. ascd.org/publications/ educational_leadership/feb08/vol65/num05/ Project-Based_ Learning.aspx (Retrieved December 29, 2014)

[15] Weyers, Matt and Dole, Jen. (2014). PBL pilot: Student work showcase. From: http://www. edutopia.org/blog/pbl-pilot-student-work-showcase-mattweyers-jen-dole (Retrieved December 29, 2014)

[16] Department of Education order 73, series 2012. Guidelines on the assessment and rating of learning outcomes under the K to 12 Basic Education Curriculum

[17] Fraenkel, Jack R. and Wallen, Norman E. (2007). How to design and evaluate research in Education, 6th edition. McGraw-Hill International Edition.

Copyrights