Game-Based Learning (GBL) in Teaching Primary Mathematics

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Original research Article

ABSTRACT

Aim: Determine the effectiveness of the Game-Based Learning(GBL) using theSnake-and-Ladder mechanical game boarding in teaching primarymathematics like addition, subtraction, multiplication and division of wholenumbers.

Methodology: Descriptive and experimental method. In descriptive method,where the developed mechanical Game-Based Learning, validated by eighty (80) pre-service teachers as major teaching strategy in primary mathematics and tested its' effectiveness using the pre and post-test design.

Results: In validating the mechanical GBL (Game-Based Learning) –A mathematical Snake-and-Ladder game boarding in eighty (80) pre-service teachers for their practicum-classroom demonstration, manifested agreeable perceptions (x =4.30) terms of technical quality, content quality and instructional quality. Using the mechanical GBL as major instructional aids in teaching basicmathematics got a very satisfactory (x = 3.50) respondents' responses in theactual classroom demonstration.

Recommendation: Mobile Apps of GBL(Game-Based Learning) development.

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1. INTRODUCTION

Game-based learning (GBL) has emerged as innovative learning technique that can increased student motivation, emotional involvement and enjoyment [1]. Hence, the author developed a localized and mobile snake and ladder, a kind of Game-based learning (GBL) that could enhance the learner's performance in the four (4) basic operations of mathematics. The author used the concept of the snake and ladder game board as the main variable of the study. Nachiappanet Al [2] found out in their study that using snake and ladder game enhances the cognitive development of the student with learning difficulties in learning mathematics. During this 21st century where digitization of mathematics education, particularly, in the teaching and learning methods, reinforces the author's desire to integrate and innovate the snake and ladder concepts into digital media like mobile applications. Mulyawati and Windiyani [3] emphasized that the use of the snake and ladder learning media have a positive impact on their learning outcomes of elementary school students. This research started from classroom based activities into a developmental research so as to create a mobile apps that copies and pastes the mechanics of the localized snake and ladder game board. Its' effectiveness was tested during the COVID -19 pandemic when face to face learning was not implemented due to the situation.

1.1 Objectives of the Study

Primarily, this study aimed to develop a localized innovative and effective Game-Based Learning (GBL) in teaching basic arithmetic like addition, subtraction, multiplication and division using the concept of snake-and-ladder-a-like game board.

2. LITERATURE REVIEWED

In the developing the game board particularly the mechanics, rules and levels, the author used the snake and ladder game board as the main variable in the Game-Based Learning(GBL). Tolentino and Roleda [4] emphasized that GBL should have five (5) main elements namely; (i) points; (ii) badges; (iii) leader boards; (iv) Rules; and (v) Levels. Without these any or all of these elements can't be considered as gamified classroom. According to Ke et al. [5], Game-Based Learning (GBL) engagement occurs in multiphase development that proceeds from pure effective engagement to a cognitive engaged, psychological experience and potentially to a conscious and necessitated interactions with the gaming situated learning content. Versoza et al. [6] commented that mobile GBL has a potential to promotes children's ability to see two-digit numbers in relation to tens and ones as one major goal of elementary school mathematics. .In establishing how the Game-Based Learning (GBL) is effective in the performance of the students, particularly, in mathematics. Shute et al. [7] suggested it's a data-driven, performance-based assessment as the basis for adaptation and how GBL works. This is what the Philippine basic education needs, a teaching strategy that creates a huge impact on the performance level of the students. For this 21st-century teaching and learning process, it need to address the outcome-based learning of each learner, and the suggested teaching strategy using educational games. Stenholm et al. [8] emphasized that all games design elements that align well with established learning theories, such as social constructivism. Further, they concluded that educational games are used for educational purposes: such games can take a variety of forms from card games to board or digital games. Landicho et al. [9] explained in their study that the incorporation of gamification into classroom activities has shown positive results in terms of student's performance and productivity. In their research paper, Qian and Clark [10] found that games can promote meaningful learning by providing students with adaptive challenge, curiosity, self-expression, discovery, immediate feedback, clear goals, player control, immersion, collaboration, competition, variable rewards and low-stake failures.

This is the reason why the proponent of the study wants to increase the performance of the students in terms of basic operation of numbers, but it should be started in the teaching-learning process, where the teacher should know how to deliver the GBL effectively using any kind of board or digital educational games. The integration and development of GBL in Philippine mathematics education is still in its early stage. When COVID-19 pandemic hit the education sector, mathematics education still used a modular strategy whose main problem is the accessibility of internet connections. Historically, according to Laguador [11] the Philippines education has available computer resources overstretched into four hundred twelve pupils into one computer (412 :1) at the primary level and has the least proportion of educational institutions while Internet, fixed broadband,

Internet Assisted instruction by the level of education. He emphasized that many secondary classroom teachers and academic administrations remain uncertain about how to implement new technologies to replace outdated forms of classroom instruction.

3. METHODOLOGY

This study uses a descriptive mean in analyzing the evaluation and perceptions of the respondents in the localized snake and ladder game board and tested its effectiveness in teaching the four(4) basic operations using pre-test and post-test design. The study was descriptive-evaluative with the class of Bachelor of Elementary Education (BEED) 4E and 4D composed of eighty(80) graduating students of the College of Teacher Education(CTE), Sultan Kudarat State University(SKSU), 2nd semester school year 2017-2018 in their subject Math 6 entitled "Methods and Teaching strategies in Elementary mathematics". Game-based learning(GBL) was introduced to the eighty (80) respondents and its effectiveness was tested during the actual classroom demonstration. The classroom demonstration was the main requirement of the subject matter. During the actual demonstration the student teacher-in-charge, group the teaching-learning process, with the main topic revolving around basic operation of numbers as part and parcel of the competency in basic mathematics. The remaining respondents acted as their learners and at the same time, the raters of the group. The rating forms used are the classroom observation form (Annex A) and the quality instructional tools evaluation form (Annex B).

In Philippine basic education, where learners mostly come from the rural areas, where digital classrooms are not very accessible, therefore, the classroom teacher needs to improve the instructional materials, like mechanical game-based learning. A *Scimazing Game* (Science-Physics and Amazing Game combined) developed and conducted by Membrebe and Tiu [12], proved the effectiveness of this mechanical game-based learning as shown by the evident increase on the academic achievement of the students in science, upon using this out-door-based teaching.

Fig. 1. A localized snake and ladder game board

The author used the snake and ladder game board, and innovated the mechanics to integrate it into the basic mathematics operations. This is an additional process that really enhances the mastery and there is learning by doing as combine in the development of mathematical skills and critical thinking. Below is the illustration on how the localized snake and ladder game board works.
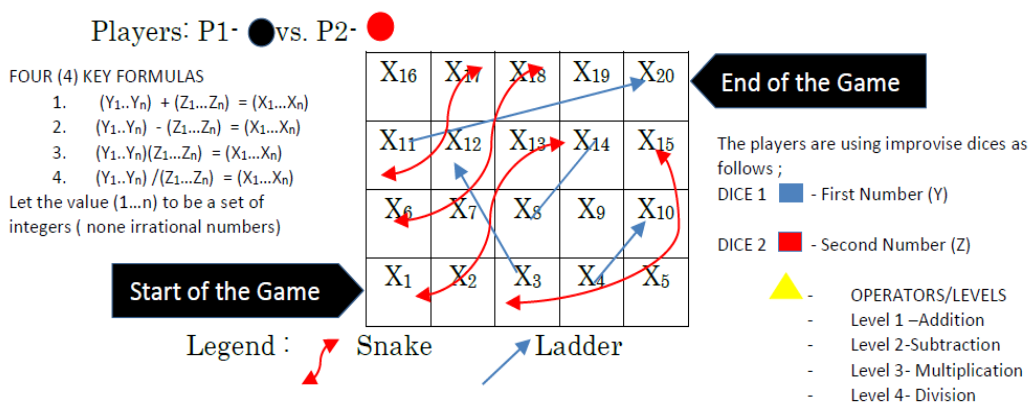

Illustration 1. The mechanics and how localized snake and ldder like game board works

In illustration 1the original rules and mechanics of snake and ladder are still the same. What the author innovate is the opponents side, where the author inserted the mathematical concepts, particularly, in the arithmetic operations of throwing of the dice which indicates the variables of $(Y_1….Y_n)$ and $(Z_1….Z_n)$ as shown in the four key formulas. The leveling of the games should vary in the degree of difficulties like in level 1 for addition, level 2 for subtraction, level 3 for multiplication and level 4 is for division. The main numeric variable denoted as $(X_1…X_n)$ also uses the leveling scheme as by ones, tenths, hundreds up to the introduction of algebra like algebraic expressions probably in like terms as expected. The main respondents vary in their capacity in terms of the mathematical abilities and knowledge. They can go into a difficult level depending on the Grade level and its lesson content.

In this COVID-19 pandemic era where no face to face learning has been done in the basic education, there is a limitation in the conduct of the research which the main respondents are children. In this case, the BEED third year students have an undergraduate thesis which the author also there adviser and recommended and highly suggested the testing of Gamification Technique (GT) in a small group of children in a certain Purok of Tacurong City where the student researchers also live in that place. The three(3) student researchers conduct in a two different place where they separate the experimental and non-experimental group in conducting and gathering of data. Below are the pictures of the two groups while doing a Gamification technique (GT) and none-Gamification Technique (nGT).

The Gamification Technique (GT) happened to the different house of the respondents where the student researchers are going in that area, while compare to a none-Gamification technique(nGT) go in the a big and open area like a Chapel, that is nearby the respondents. The conduct of experimentation almost done in one week and the proponents are successfully gathered the needed data.

The Fig. 2(a-b) show that teaching basic mathematics, particularly, the four (4) basic operations can be fun. There is excitement as seen in the faces of the respondents, therefore basic mathematics can be learned through mechanical GBL without hesitation or worry to be contaminated with a COVID-19 virus.

Fig. 2a. The GBL used by the respondents Fig. 2b. Respondents at work, using GBL

Fig. 3a. The none game-based learning (GBL) respondents

Fig. 3b. The traditional methods in teaching basic math

Fig. 3 (a-b) where none game-based learning (n GBL) is being done to this group of respondents, show the respondents as typical learners who listen carefully to the lessons given by the researcher. This was conducted in the open and big area like the chapel located nearby.

4. DISCUSSIONS AND RESULTS

4.1 Localized Snake and Ladder Game Board Designs

Fig. 4. Shows how the GT works with the pre-service teachers

The author introduced the localized snake and ladder game board designs among the eighty(80) graduating BEED students taking their subject 'Math 6' and came out with unique designs. One of those design is shown in Fig. 1. In order to determine the usability and perceptions as additional teaching aids in teaching basic mathematics, they followed the mechanics and rules. Then they rated the localized snake and

ladder in their practicum for actual classroom demonstrations.

Table 1 indicate a *descriptive mean of 3.5* with a description meaning of *Very Satisfactory (VS)*. It implies a normal description of the graduating class of teacher education. Among the five (5) strands, the visual aid as the lowest value. This means that the testing of the GBL is not yet organized as it shown be. When personality is concerned, there is a need for improvement and become full of confident to become a better teacher. The third in lowest are their communication skills which are very important in the teaching-learning process. The highest is, of course, the methods, strategies in delivering the lessons which are very new to the fourth year education respondents. The interweaving of the traits and characteristics of being the best teacher is anchored on the content knowledge and transverses into all other aspects. Game-Based Learning (GBL) improves productivity of the teacher as reflected in all criteria. Results also reflect students' achievement, particularly, in mathematics education.

Table 2 indicates a *descriptive mean of 4.30* with a descriptive meaning of *agree.* This means that the GBL is quite good as new to the respondents. The content and technical qualities got the highest rating while the instructional qualities got the lowest mean score. This means there is a need for a deep connection between the subject matter and the localized snake-and-ladder-a-like game board.

Table 1. The mean value of each criterion in the actual classroom demonstration using Gamification Technique (GT)

Criteria	Mean(x)
1. Lesson plan/Organizational	19.313
2. Instructional Materials/Visual aids	11.750
3. Mastery of the subject matter/methods/techniques.	20.646
4. Self-confidence and poise/Teacher's personality	15.004
5. Student rapport/communication skills	17.894
Mean	**3.5**

*Legend: Outstanding- 5; Very satisfactory-4; Satisfactory- 3 ; Fair -2 ; Poor- 1*

Table 2. Perceptions in terms of qualities of GBL

Perceptions	Mean (y)
A. Content Quality	35.088
B. Instructional Quality	31.983
C. Technical Quality	35.370
Mean	4.30

Legend: Strongly Agree- 5; Agree-4 ; Disagree- 3 ; Strongly disagree -2 ; Not applicable- 1

Table 3. The ANOVA results between the two groups (GBL and none-GBL)

ANOVA Table			Sum of Squares	df	Mean Square	F	Sig.
GBL* None-GBL	Between Groups	(Combined)	17.133	4	4.283	.126	.970
	Within Groups		339.800	10	33.980		
	Total		356.933	14			
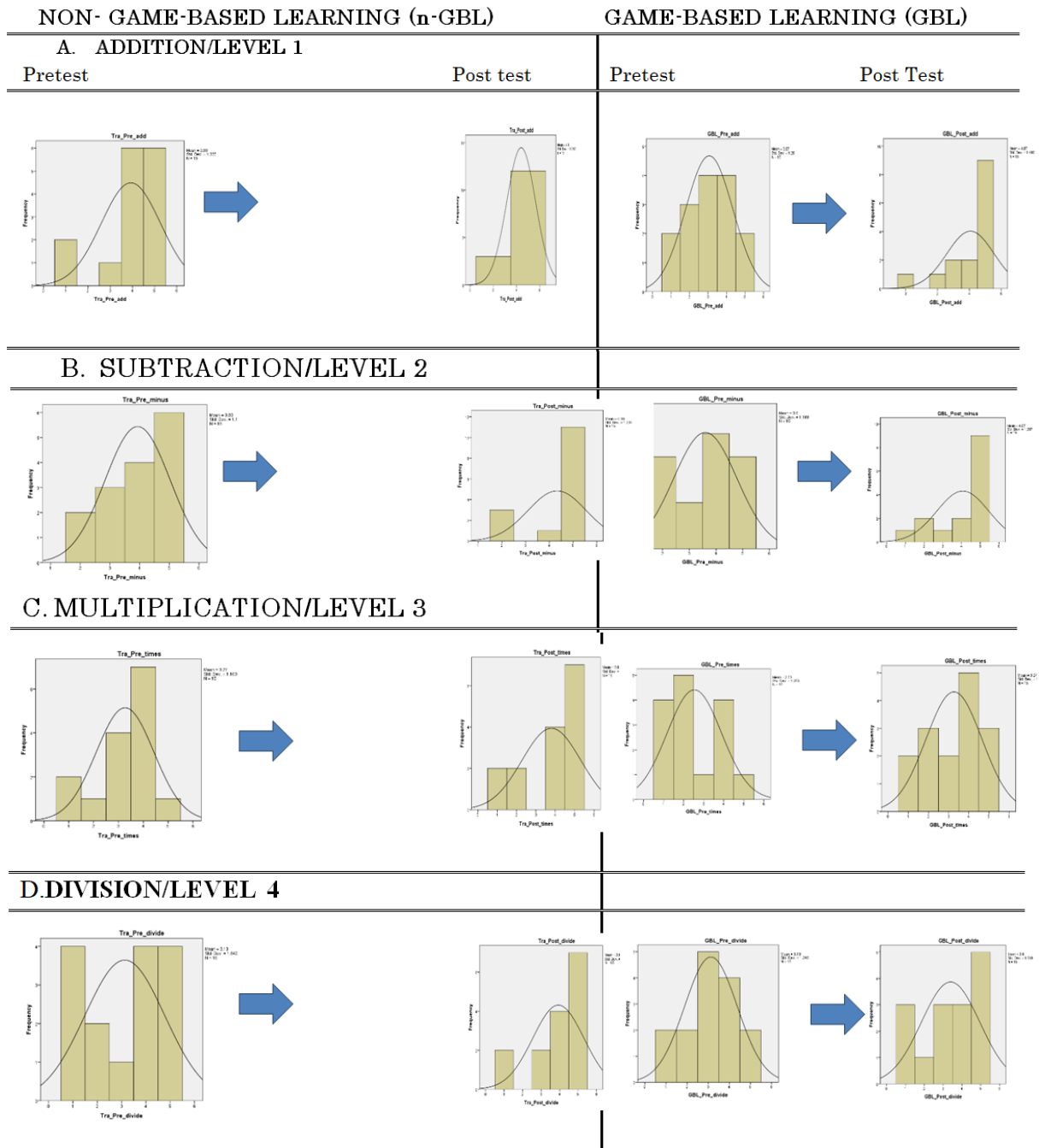
Fig. 5. The descriptive graphical presentation in Pre/Posttest of GBL and nGBL

4.2 Effectiveness of Gamefication Technique (GT) in Teaching Four (4) Basic Operations

How about the significant difference between the GBL (Game-Based Learning) Technique and n-GBL (none Game-Based Learning?

There is no significant difference between the GBL and none-GBL where $\alpha = 0.05 < 0.970$, $F_{(4,10)} = 0.126$, $p = 0.970$. This means that there is no significant impact from the use of the GBL in teaching the four (4) fundamental operations of basic mathematics still. This process needs a further improvement in the conduct of the study due to COVID-19 restrictions. The author and the student researchers need close coordination in the conducting and gathering of the data. Limited consultation and time are a factor, but, the most important things in this study are the implementation and testing of this localized snake and ladder like game board.

The next illustrations show a descriptive graphical presentation per arithmetic operations in none-Game-Based Learning (n GBL) and Game-Based Learning (GBL).

Fig. 5 describes the difference in achievements scores of the respondents between the none Gamed-based learning (nGBL) and Game-based Learning(GBL). Level 1 and level 2 show that the GBL is effective and the rest have the same descriptive presentation.

5. CONCLUSION

The 21st-century education focuses on the learning style of learners. The increase of manipulative learning and teaching style creates many novel challenges to educators ,particularly, those in content-based discipline like mathematics. Mathematics is one of the difficult subjects that need great attention from 21st-century educators' who generally use the purely stand-alone lecture method. Additionally, the Game-Based Learning (GBL) in Philippine Basic education is hard to observe because of the lack of concepts in content. It is not easy to prepare on the part of the teacher at the same time there is lack of instructional materials, particularly, textbooks and resources.

From the preceding discussion and analysis of results, these essential conclusions are drawn:

1. Becoming a 21st-century teacher, innovation and creativity are badly needed by 21st –century teachers particularly in elementary mathematics, where Game-Based Learning (GBL) is highly usable; a localized snake and ladder like received a good rating from the incoming teachers.
2. The quality output of teachers inside the four corners of the classroom vary and depend largely on the teaching strategy that they might use Game-Based Learning (GBL) obtained the highest rating of 4.30 and is highly recommended for the matter.
3. The Game-Based Learning (GBL) remains interwoven with all other traits, characteristics of features of the classroom instruction.
4. There is a strong transformation from the manual game board into electronic game board as the main peripherals in this e-classroom (electronic classroom) specially during this COVID-19 pandemic.
5. The effectiveness of the GBL in addition and subtraction operations is higher in terms of pre and post-test means, compared to the multiplication and divisions.
6. In this blended learning where mostly online instructions are being undertaken, Gamification Technique (GT) is highly recommendable.

Platz, Juttler & Schumann [13] explained the used of game-based learning (GBL) is gaining importance in and out of schools and linked to high expectations in terms of motivation and learning success. In this case, the localize Game-Based Learning (GBL) developed by the author is highly motivational and there is a learning gained by the respondents particularly the pupils involved.

6. RECOMMENDATION AND FUTURE DIRECTIONS

The present generation mostly prefers mobile apps, and are mostly hooked with social media websites, which has good implications to digital education. The study of Miguel et.al. [14],made a mobile game application link to their android cellphones while teaching a *Grade 8 Araling Panlipunan* lesson and found out that the students became proficient in that subject. The author wants to develop a mobile applications or a digital version of the localized snake and ladder like using a PhP computer programming language as suited for a game-based programming. The author used the flowchart for pseudo codes for the PhP programmer in systematic coding.
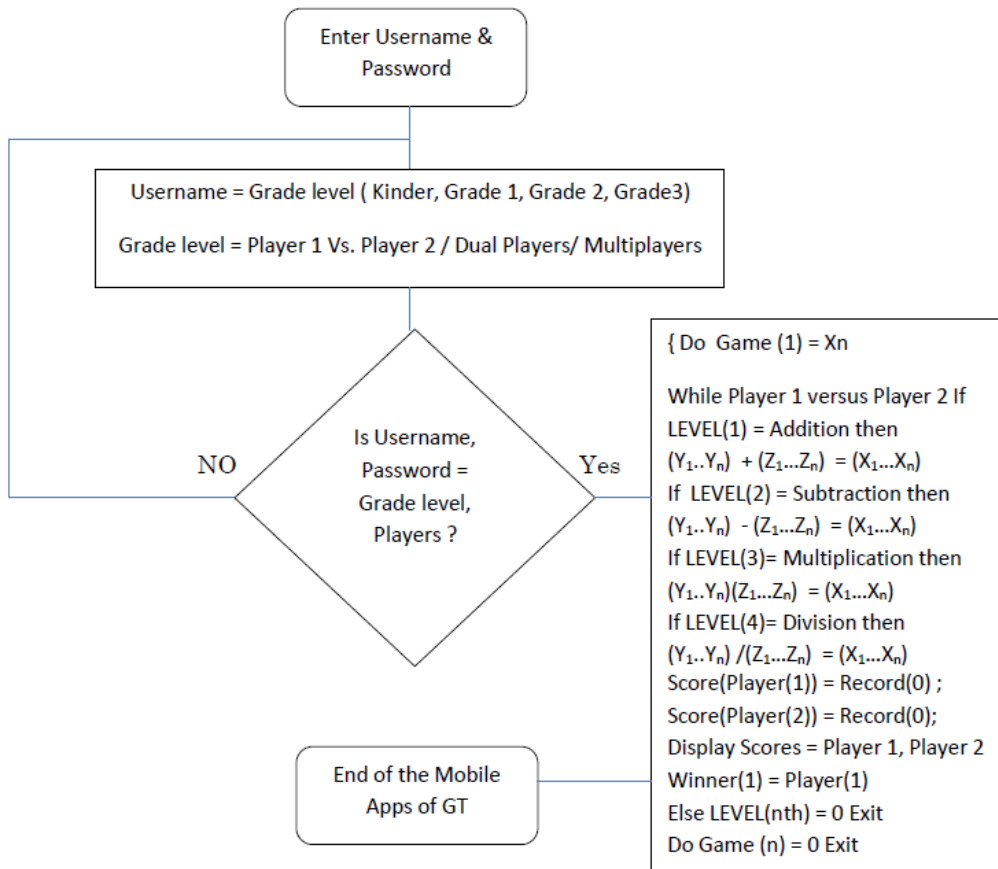
Flow Chart 1. The SAD (System Analysis Design) of the Proposed Mobile apps of GBL
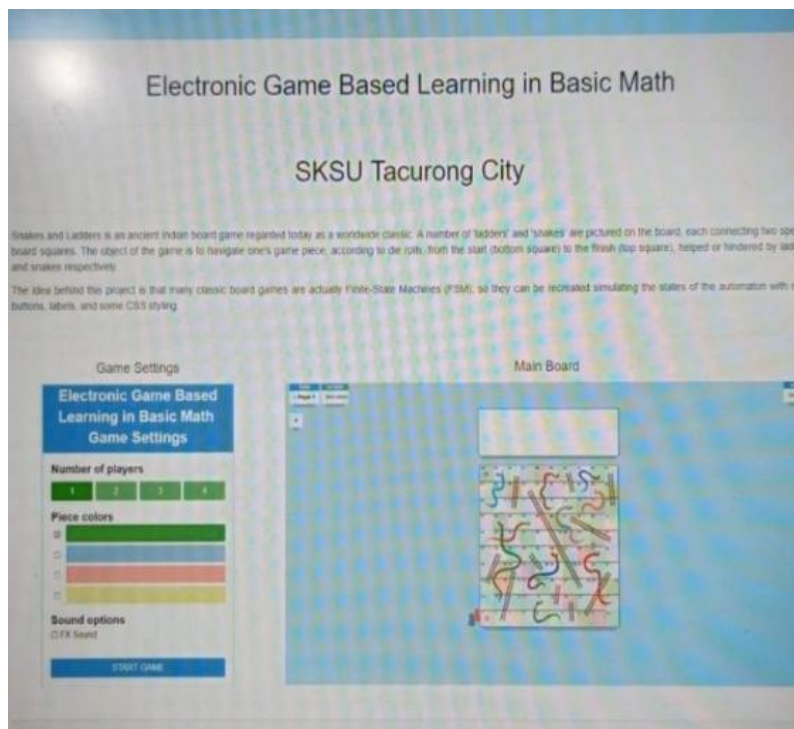

Fig. 6. The screen shot of the proposed mobile apps of Gamification Technique (GT)

As system analyst of the proposed mobile apps of GT. The author designed how the mobile application works as shown in the Flowchart 1 - a SAD(System Analysis and Design), as needed in creating a computer system/web-based programming system and to ensure that the flow of the computer programs realign with the computer programming codes to be encoded by a compute programmer. Due to lack of web page / game based programming knowledge the mobile apps of the GT is not fully executable and recognized.

CONSENT

ACKNOWLEDGEMENT

COMPETING INTERESTS

Author has declared that no competing interests exist.

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ANNEX A

CLASSROOM OBSERVATION FORM
MATH 6

Group's number: _____
Course: _____
Subject: _____
Topic: _____

	5 Outstanding	4 VS	3 S	2 FAIR	1 POOR
I. Organizational/Lesson Plan					
1. Objectives are stated in behavioral terms.					
2. There is congruence between:					
2.1 Objective and subject matter					
2.2 Objective and teaching procedure.					
2.3 Objective and student activities; and					
2.4 Objective and evaluation					
II. Instructional materials/Visual Aids					
1. Visual aids are congruent with objectives					
2. Visual aids are informative and can attract the attention of students					
3. The teacher is creative and resourceful in creating visual aids					
III. Mastery of the Subject Matter/Methods/Techniques					
1. The teacher has the mastery of the subject matter.					
2. Methods/techniques used is/are suited to the needs and capabilities of the students.					
3. The teacher is creative enough to adapt his/her method to the student's capabilities					
4. Instructional materials and other examples are used to illustrate the lesson.					
5. The teacher relates the subject to current issues.					
6. The teacher promotes desirable values & habits among the students.					
IV. Self-Confidence and Poise/Teachers Personality					
1. The teacher has a pleasing personality and modest.					
2. The teacher is skillful in asking questions.					
3. The teacher is free from mannerism that tends to disturb the student's attention.					
4. The teacher's personality is strong enough to command respect and attention.					
V. Student Rapport/Communication Skills					
1. The teacher motivates instructive conversations among students.					
2. Order and discipline are present in the classroom					
3. The teacher speaks clearly with a well-modulated voice.					
4. The teacher uses correct grammar in speaking/writing board work.					
5. S/heobserved the correct direction.					

Comments/Remarks_____

_____
Conformed: _____

_____
Signature over Printed /Date

ANNEX B

INSTRUCTIONAL TOOLS
EVALUATION FORM
MATH 6

Group's number: _____Course: _____Age:_____Subject: _____Topic: _____

Scale : 1- Not Applicable ; 2 - Strongly disagree ; 3- Disagree ; 4- Agree ; 5 - Strongly Agree

	1	2	3	4	5
I. CONTENT QUALITY					
1. The content(context) is scientifically adequate for the lesson.					
2. It emphasizes active learning.					
3. It is well organized.					
4. It is relevant to learning objectives.					
5. It reaches power ideas to the lesson proper.					
6. It allows the development of multiple intelligences.					
7. The lesson proper is congruence to the instructional tools					
8. The topics with the instructional tool are interesting					
9. The content is ethics, gender, and other stereotypes					
II. INSTRUCTIONAL QUALITY					
1. It provides appropriate on the accuracy of the learner's answer.					
2. It is of high educational value					
3. It is good enhancement /supplement to the curriculum					
4. It addresses the needs and concerns of learners.					
5. It facilitates collaboration and interactive learning					
6. It integrates the student's previous experience					
7. It constructed appropriately to the level of the learner's need					
8. It reflects current in the mathematics instructions					
III. TECHNICAL QUALITY					
1. The Instructional is easy to operate					
2. It allows the learner to control the pace					
3. It is well organized					
4. The operation/mechanical aspect is clear					
5. The constructive layout and design are attractive					
6. Intended learners can easily and independently use the instructional tool					
7. It is unique and suited to the lesson proper					
8. It operates quickly, easy to understand					
9. The instructional tool is aesthetically pleasing.					

Comments/Remarks_____

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Conformed: _____

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Signature over Printed /Date