Development and Validation of Survey Instrument on Game-Based Learning Approach (SIGBLA)

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Joana De Guzman Quinto
Science Education Department, De La Salle University, Manila, Philippines
joana_quinto@dlsu.edu.ph

Abstract—The purpose of this study was to develop and psychometrically evaluate an instrument that analyses technology game-based learning holistically across a number of critical characteristics. On the other hand, qualitative feedback is difficult to collect in the absence of a quality rating method. There is an urgent need for a comprehensive scale that has been psychometrically validated and is suited for assessing game-based learning knowledge, perceptions, and attitudes. The approach for developing and validating these new scales followed current best practices for scale development and validation. As a result, a mixed-methods design was used, which comprised the establishment of an item pool, expert review, a questionnaire pilot study, exploratory factor analysis (N = 174 and N = 284), and parallel analysis. The Survey Instrument on Game-Based Learning Approach (SIGBLA), an instrument for assessing knowledge perception and attitudes towards game-based learning, has been developed. It comprises of three subscales. The SIGBLA was determined to have exhibited content validity, dependability, and internal consistency. The tools were developed and validated using data from assessments of a number of educational games. This method is adaptable to a wide variety of instructional digital games and can be used to ascertain which components of a game contribute to users' knowledge, perceptions, and attitudes. Additionally, it is relevant to a variety of other sorts of digital games used in the educational sector. As a result, the SIGBLA may be used to characterize the psychometric properties of various types of digital games played by various sorts of users. Students demonstrated good knowledge and positive attitude towards game-based learning. In order to develop positive impressions, knowledge, and attitudes among students, educational games must be implemented in the classroom. Educational games can be used to improve cognitive knowledge and foster favorable attitudes toward the subject.

Keywords—game-based learning, digital games, assessment instrument, technology, learning, reliability

1 Introduction

In educational contexts, digital game-based learning has gotten a lot of attention. The beneficial association between Digital Game Based Learning (DGBL) and motivation has changed instructors' focus to acquiring these approaches as a substitute for more traditional methods [1]. [6], for example, conducted empirical study on the links between game enjoyment, learner motivation, and test scores. The study discovered a positive association between gaming enjoyment and motivation in an educational setting. Similarly, a study established the impact of digital games on students' mathematics achievement. The children had increased their level of engagement in the classroom as a result of the activities [7].

By providing students with opportunities to learn while having fun, digital game-based learning helps students maintain their concentration on their studies. Math classes incorporated digital game-based learning. It demonstrated students' good attitudes toward digital games, as they aid in attention while also providing enjoyment [13]. As a result, it is a powerful predictor of students actively participating in lectures.

Additionally, digital game-based learning can assist teachers in properly planning courses and assessing students' learning progress. According to [13], DGBL benefits teachers by motivating students to participate in class activities and enhancing their learning performance. As a result, teachers can utilize digital games as a reflecting tool to assess students' learning and help them improve their performance. Additionally, it was said that digital games assist students in being active and energetic during lectures [5], resulting in the formation of a successful learning environment. Despite the growing number of teachers that include digital games into the classroom, many educators remain unaware of the educational potential of digital games. The explanation for this could be that they are unaware of or unfamiliar with games that promote contextual learning and 21st-century abilities. [9] discovered that the majority of teachers in their survey were unfamiliar with or had limited experience with massively multiplayer online games and were unaware of their educational usefulness.

Moreover, this study will lay the groundwork for the researcher to create an Interactive Mobile-Based Digital Game for Mathematics Education. By providing insight into students' and teachers' knowledge, viewpoints, and attitudes, the findings of this study can assist educational game producers in producing more effective games. Additionally, because the feedback was obtained directly from the target population, instructional game producers tended to give it more weight. However, in order to acquire meaningful results, it is vital to elicit useful feedback from participants. As a result, the questionnaire's design and quality are crucial.

1.1 Significance of the study

While prior research has provided scale-level insights into game-based learning, the majority of extant instruments are based on a small number of digital game titles or genres. The purpose of this study will serve as a foundation for the researcher's development of an Interactive Mobile-Based Digital Game for Mathematics Education. The study's findings can be used to improve understanding of student and teacher preferences and attitudes toward educational games.

1.2 Review of related studies

While a growing number of teachers include interactive games into their courses, many are unaware of their potential pedagogical value. This could be due to their ignorance of or disinterest in games that promote contextual learning and 21st-century talents. According to [9], the majority of pre-service instructors were unfamiliar with or had limited experience with massively multiplayer video games and were unaware of its instructional usefulness.

Similarly, [3] discovered that teachers were often suspicious of video games' educational benefits, owing to their lack of familiarity with the medium, and they remained doubtful even after playing a variety of titles. [10] discovered that the majority of teachers who use games do so in shorter-form genres like drill-and-practice games. While drill-and-practice games can help children memorize facts and acquire required skills, they cannot teach complex subject or higher-level skills. While contemporary game researchers have produced and built ground-breaking digital games or game-based learning environments capable of enhancing 21st-century abilities, teachers continue to struggle with picking appropriate games. According to [8], all participants considered the process of selecting educational computer games to be challenging, given the majority of games were inappropriate for young children and did not align with the Early Childhood Education (ECE) curriculum. Including teachers in the game design process is one method for overcoming this barrier. Collaboration between teachers, researchers, instructional designers, and game developers would result in the creation of excellent digital learning games for classroom teachers to employ. When building such games, it is vital to consider the perspectives of teachers and pupils. To overcome this gap, this study assessed teachers' and students' knowledge, perspectives, and attitudes about game-based learning.

The theoretical foundation for developing and validating this survey is the Theory of Planned Behavior (TPB). TPB is a social psychological theory that links beliefs, attitudes, norms, intentions, and action. This indicates that an individual's behavior while dealing with technology is determined by his or her intention to do so. In social research, the TPB has been widely used to explain and forecast people's behavior or intention to behave in three dimensions: attitude toward the action, subjective norms, and perceived behavioral control [11].

1.3 Objectives of the study

This study aimed to design and psychometrically validate an instrument that holistically assesses game-based learning, specifically it aimed to:

- What is the reliability and validity evidence of the developed instrument?
- What is the students’ knowledge, perception, and attitudes on game-based learning?
- Is there a significant relationship between students’ knowledge, perception, and attitudes on game-based learning?

2 Materials and methods

2.1 Population and sample

The study include 174 mathematics professors and 284 pupils. The number of students and teachers used to validate this tool was estimated using a one-to-five to one-to-ten item-to-participant ratio [2]. Additionally, given the purpose of this survey was to build a universal instrument that could be utilized across a broad range of teacher professional training programs and organizations, the sample was purposefully chosen to be as diverse as possible.

Ninety-eight (56.3 percent) of the 174 instructors who completed questionnaires were male, while 76 (43.7 percent) were female. The average age of participant teachers is 26. (33.3 percent). In terms of time spent playing, 98 (56.3 percent) spent less than an hour per day and 76 (43.7 percent) spent 1-3 hours each day. Additionally, more than half of respondents routinely incorporate games into their classrooms 96. (56.3 percent). Additionally, the majority of respondents were engaged in digital educational games 156. (96.6 percent). (See Table 4)

Additionally, 60 (21.1 percent) of the 284 students who completed surveys were male, while 224 (78.9 percent) were female. The average age of student participants is sixteen years and twelve months (43.7 percent). In terms of time spent playing, 80 (31.1 percent) spent 1-3 hours every day on digital games. Additionally, the majority of respondents preferred games in class 31 (10.9 percent) frequently, 55 (19.4 percent) usually, 134 (47.2 percent) occasionally, 32 (11.3) seldom, and 32 (11.3) for those who did not like GBL in class. Additionally, the majority of respondents were engaged in digital educational games 267. (94.01 percent).

2.2 Statistical techniques used in the present study

The validity and reliability of the SIGBLA were determined as follows: To establish concept validity, exploratory component analysis was done (EFA). Kaiser–Meyer–Olkin (KMO) values were used to establish sample size, and Bartlett's test of sphericity was employed to determine the data's suitability for factorization. EFA was used to identify common components in the latent variable using SPSS 20.0. PCA was chosen for this study because the primary objective was to investigate the theory of training transfer systems rather than to do data reduction. Parallel analysis was used to identify the amount of variables to extract, and the varimax rotation method was used to discover important components. The loading and cross-loading thresholds were set to 0.4, and items with less than 0.4 loading and larger than 0.4 cross-loading were deleted. This method was repeated until a simple structure was created with maximization of loadings on putative factors and minimization of loadings on others. Internal consistency was determined using Cronbach's alpha coefficients. For statistical analysis, the Statistical Package for the Social Sciences (SPSS) version 20.0 and Monte Carlo PCA were employed. Also correlational analysis was used to determine the relationship between variables.

2.3 Data analysis and interpretation

Exploratory factor analysis

Factorability. The KMO and Bartletts Sphericity tests were used to validate the factor analysis. As seen in Table 1 the KMO value exceeded the minimum threshold of 0.60. The values.817 and.932, demonstrating their eligibility for factor analysis, were deemed "meritorious" and "marvelous," respectively. Additionally, the Bartlett's Test of Sphericity revealed a very significant value (P =.000), showing that the correlation matrix is significantly different than the identity matrix.

Table 1. KMO and Bartlett's test

		Teachers	**Students**
Kaiser-Meyer-Olkin Measure		.82	.93
Bartlett's Test of Sphericity	Approx. Chi-Square	17301.85	2145.64
	Df	174	285
	Sig.	.00	.00

Finally, we determined scale factorability by analyzing communalities and factor loadings. Additionally, the communality value is utilized to decide whether a variable should be included or excluded from the factor analysis. All items with a value less than 0. 5 were removed. Following an initial assessment of the data, it was determined that one item on each survey had a communality of less than 0.50, and so was deleted.

Factor extraction. Due to the non-normal distribution of the data, Principal Component Analysis (PCA) was chosen as the major extraction method. A preliminary EFA found that several inter-factor correlations were more than 0.32 for the rotation method. This information justified the use of varimax rotation. Additionally, a factor retention approach, such as Monte Carlo PCA for parallel analysis, was used to determine the number of factors to retain. Scree plot analysis found a five-factor solution for teachers and a six-factor solution for students (Figure 1 and 2). However, a similar investigation using Monte Carlo techniques discovered three possible reasons for each instrument. Only three components were maintained, as indicated by the data in Table 2. Components 4 and 5 were dropped as factors due to the fact that their predicted eigenvalues were not surpassed in parallel analysis.

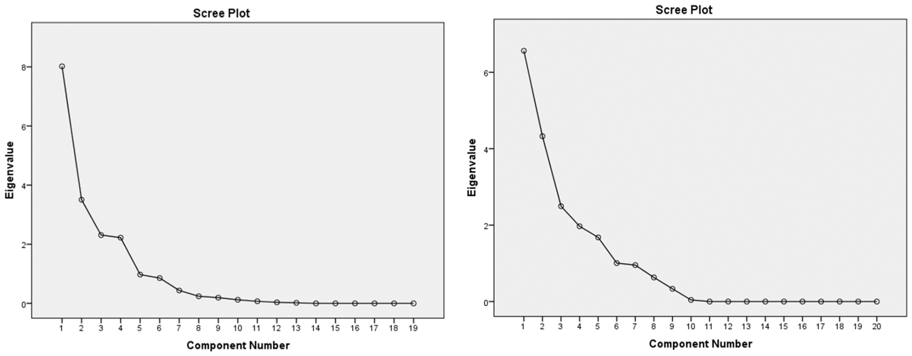

Fig. 1. Scree Plot for an unrotated factor solution Teacher (R) and Students (L)

Table 2. Results for parallel analysis (Students)

Factor #	Original Data's Eigenvalue	Parallel Factors Eigenvalue
1	8.018	1.6652
2	3.506	1.5281
3	2.311	1.4224
4	1.221	1.3517
5	.973	1.2862

Moreover, as seen by Table 3, three components were retained. Components 4,5, and 6 were not retained as factors since their eigenvalues did not exceed those predicted by parallel analysis.

Table 3. Results for parallel analysis (Teachers)

Factor #	Original Data's Eigenvalue	Parallel Factors Eigenvalue
1	6.562	1.4959
2	4.326	1.4110
3	2.495	1.227
4	1.171	1.2269
5	1.079	1.1791
6	1.007	1.0828

Factor solution. After eliminating the problematic item(s), the most concise and theoretically appropriate response was a three-factor approach. The three-factor solution was consistent with the parallel analysis results, accounting for approximately 66.92 percent (for a student instrument) and 72.81 percent (for a teacher instrument) of the total variation. The three variations were Knowledge, Perceptions, and Attitudes. Tables 4 and 5 detail the elements put on each component, along with their mean and standard deviation.

Items			Rotated Factor Loadings		
	Mean	Std. Deviation	Factor 1 Knowledge	Factor 2 Perceptions	Factor 3 Attitudes
1. I can determine the disciplinary content embedded in a game/ what content is being taught	3.6667	.47276	.958		
2. I can use strategies that combine content, games and teaching approaches	3.6667	.47276	.958		
3. I can repurpose an existing game for educational use	3.6667	.47276	.958		
4. I can use my knowledge of a game to ascertain what students are learning during play in a game-based classroom	3.6667	.47276	.958		
5. I can develop curricular activities to support students in inquiring into concepts related to the learning objectives of a game-based classroom.	3.6667	.47276	.958		
7. I can adapt my teaching style to different learners in a game-based learning classroom	3.0115	.94342	.773		
8. I find it more interesting to teach the subjects through online competitive games.	3.1149	.31987	.666		
12. I think digital games can be applied in many learning contexts.	3.5632	.97009	.501		
13. I think GBL can enhance students' motivation to learn	3.3448	.47668		.914	
14. I believe GBL can help students develop higher-order thinking skills	3.9195	.37918		.902	
15. Digital games can help students develop problem-solving skills	3.8333	.44440		.901	
16. Game-based Learning Approach are an effective way to teach lower level factual and procedural knowledge	3.6667	.47276		.744	
17. Digital games are an effective way to teach basic skills	3.2241	.41822		.727	-.460
18.I think learning shouldn't have fun as a necessary requirement.	3.2069	.43377		.727	.460
6. I am interested in using digital games in my classroom	3.5345	.51167			.679
9. I feel comfortable using digital games in my classroom	3.4425	.49812			.805
11. I am confident using digital games in my classroom	3.4425	.49812			.723
19. It is more flexible for me to assess my students learning.	3.2241	.41822			.642
20. I believe that game based learning in higher education will be an important teaching tool in years to come.	3.6667	.47276			.533

Fig. 2. Summary of factor loadings (Teachers)

Items			Rotated Factor Loadings		
	Mean	Std. Deviation	Factor 1 Knowledge	Factor 2 Perceptions	Factor 3 Attitudes
1. I just need a short time to know how the game is functioning	3.11	.328	.824		
2. These educational games help me to think critically.	3.11	.317	.810		
3. I feel competent and effective when playing	3.23	.634	.792		
4. Solving the given problems/tasks in games is very interesting.	3.34	.474	.765		
10. These educational games challenge my understanding of the subject.	3.66	.474	.671		
12. My ability to play the game is well-matched with the game's challenges.	3.55	.498	-.652		
20. I find it more interesting to learn the subjects through competitive online games.	3.23	.634	.603		
5. I think learning should not have fun as a requirement.	2.66	.823		.432	
6. Online competitive games enable continuous learning.	3.34	.474		.808	
7. The points-based incentive system in games is also a contributing factor to continuous learning.	3.23	.419		.807	
8. Game-Based Learning could help me learn the knowledge on mathematics.	3.32	.469		.782	
9. This "game-based learning" could help me apply what I learned.	3.34	.474		.728	
11. I believe that GBL could extend my knowledge about mathematics.	3.00	.214		.719	
16. I think activities/ tasks in educational games give me lots of benefits.	3.32	.469		.584	
19. I wish I have more opportunities to learn using this game approach.	3.10	.299		.572	
17. I prefer using games to learn compared to traditional methods in the class.	3.00	.673			.979
18.I would like to learn all education subjects using the educational game.	3.10	.299			.979
14.I hope these educational games will be available online for easy access.	3.10	.299			.979
15. I can learn according to my own pace and sequence.	3.00	.476			.541

Fig. 3. Summary of factor loadings (Students)

Chronbach's Alpha. Cronbach's Alpha values (Table 4 and 5) for the remaining 19 questions and each subscale of the Survey Instrument were greater than 0.70 for both teachers and students in game-based learning. The alpha values for the three subscales are within the "acceptable" range of internal consistency [4].

Table 4. Results of Cronbach's Alpha (Teachers)

Factor Number	Number of Items	Cronbach's Alpha
1: Knowledge	8	.826
2: Perceptions	6	.927
3: Attitudes	5	.764
Total	19	.839

Table 5. Results of Cronbach's Alpha (Teachers)

Factor Number	Number of Items	Cronbach's Alpha
1: Knowledge	7	.816
2: Perceptions	8	.826
3: Attitudes	4	.877
Total	19	.840

Final instrument. The final version of the instruments created in the study consisted of 19 items measuring three subscales, including knowledge about SIGBLA. 8 items teachers and 7 items for students; 6 and 8 items for perceptions, and 5 and 4 items for perceived attitudes toward GBLA, respectively.

Relationship between participants' perception, knowledge, and attitudes on game-based learning. Table 6 presents the relationship among the identified variables. The correlations revealed significant positive correlations between perceptions and knowledge *($r=0.780$, $P<0.01$)*, perceptions and attitudes *($r=0.286$, $P<0.01$)* and between knowledge and attitudes *($r=0.327$, $P<0.01$).* This shows that students who have positive perceptions tends to have positive attitudes and to be more knowledgeable on GBL. Also participants who has positive attitudes tends to be more knowledgeable on GBL.

Table 6. Correlation between perceptions, knowledge and attitudes

Factors	Perception	Knowledge	Attitudes
Perception	-		
Knowledge	.780**		
Attitudes	.286**	.327**	-

3 Conclusion

The performed factor analysis on Survey Instruments on Game-Based Learning presents three factors. (Knowledge, Perceptions, and Attitudes) The students perceive positively on game-based learning; however, there are still concerns about adopting the system. Implementing game-based learning in education may have various benefits and opportunities; however, challenges and barriers emerged.

Game Based Learning can also be effectively used to engage students since games can be highly engaging. Still, it will be more beneficial if interactive elements are built-in, so the students participate in an active learning process. The study is limited to students who have an average age of 16 and teachers with an average age of 27, wide range of age is suggested to vastly improved the generalizability.

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5 References

[1] Alsawaier, Raed. (2018). The Effect of Gamification on Motivation and Engagement. *International Journal of Information and Learning Technology*. 35. 00-00. https://doi.org/10.1108/IJILT-02-2017-0009
[2] Field, A. P. (2009). Discovering statistics using SPSS (3rd ed.). Los Angeles, CA: Sage.
[3] Gaudelli, W., & Talyor, A. (2011). Modding the global classroom? Serious video games and teacher reflection. Contemporary Issues in Technology and Teacher Education, 11(1), 70–91.
[4] George, D., & Mallery, P. (2003). SPSS for Windows step by step: A simple guide and reference, 11.0 update (4th ed.). Boston, MA: Allyn & Bacon
[5] Licorish, S.A., Owen, H.E., Daniel, B. et al. (2018). Students' perception of Kahoot!'s influence on teaching and learning. RPTEL 13, 9 (2018). https://doi.org/10.1186/s41039-018-0078-8
[6] Imlig-Iten, Nina & Petko, Dominik. (2016). Learning with serious games: Is fun playing the game a predictor of learning success?. British Journal of Educational Technology. 47. 151-163. https://doi.org/10.1111/bjet.12226
[7] McCarthy, E., Tiu, M., & Li, L. (2018). Learning math with curious George and the odd squad: Transmedia in the classroom. Technology, Knowledge and Learning, 23(2), 223-246. https://doi.org/10.1007/s10758-018-9361-4
[8] Sancar Tokmak, H., & Ozgelen, S. (2013). The ECE pre-service teachers' perception on factors affecting the integration of educational computer games in two conditions: Selecting versus and redesigning. Educational Sciences: Theory & Practice, 13(2), 1345–1362.
[9] Schrader, P. G., Zheng, D., & Young, M. (2006). Teachers' perceptions of video games: MMOGs and the future of pre-service teacher education. Innovate: Journal of Online Education, 2(3), 1–10.
[10] Takeuchi, L M., & Vaala, S. (2014). Level up learning: A national survey on teaching with digitalgames. Retrieved from http://www.joanganzcooneycenter.org/wpcontent/uploads/2014/10/jgcc_leveluplearning_final.pdf
[11] Patterson R. R. (2011). Using the theory of planned behavior as a framework for the evaluation of a professional development workshop. *Microbiology education*, *2*, 34–41. https://doi.org/10.1128/me.2.1.34-41.2001
[12] Pham Van, L., Jean, C., Meyrueis, V., Gazo, C., Mantelet, F., Gueguan, J., Buisine, S., & Segonds, F. (2022). IdeAM Running Quiz: A Digital Learning Game to Enhance Additive Manufacturing Opportunities Discovery. International Journal of Emerging Technologies in Learning (iJET), 17(10), pp. 32–50. https://doi.org/10.3991/ijet.v17i10.25695
[13] Tabachnick, B. G., & Fidell, L. S. (2007). Using multivariate statistics (5th ed.). Boston, MA: Pearson. Takatalo, J., Häkkinen, J., Komulainen, J., Särkelä, H., & Nyman.
[14] Wang, A.I., & Lieberoth, A. (2016). The effect of points and audio on concentration, engagement, enjoyment, learning, motivation, and classroom dynamics using Kahoot.
[15] Zamanzadeh, V., Rassouli, M., Abbaszadeh, A., Majd, H., Nikanfar, A., & Ghahramanian, A. (2014). Details of content validity and objectifying it in instrument development. Nursing Practice Today, 1, 163-171.

6 Author

Joana De Guzman Quinto is a professional teacher. Since joining the Far Eastern University- Diliman, Quinto has been involved with mathematics and research studies. She holds a Bachelors' degree in Secondary Education major in Mathematics and a Master's degree in Mathematics Education (scholar of the Department of Science and Technology, Science Education Institute (DOST-SEI) – National Consortium for Graduate Science and Mathematics Education (NCGSME).) from Central Luzon State University. Ms. Quinto is currently taking Doctor of Philosophy in Science Education-Mathematics. She handles several courses related to mathematics in the undergraduate programs, and she had published several studies.

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