Original Research Article

Educational Game-Based Design Training on Newton's Laws for Physics Teachers: A Need Analysis for Module Development

ABSTRACT

Game-based learning (GBL) is one of the approaches that could foster students' learning, motivation and the development of 21st-century skills. Past studies have shown that students face problems learning Newton's laws. Educators are eager to integrate GBL into their teaching but often lack the knowledge and training.

Aims: This study was conducted to identify the problems teachers face while teaching Physics, the implementation level of GBL in Physics classrooms, the need for a training module development and the module's requirements.

Study design: Quantitative research design.

Place and Duration of Study: This study was conducted in Malaysia between June 2022 and October 2022.

Methodology: A stratified sampling method was used, involving 338 secondary school Physics teachers in Malaysia answering an online need analysis survey. Quantitative data were analysed using SPSS software to obtain the percentage, mean and standard deviation.

Results: The findings showed that the significant challenges faced were a lack of experience in implementing GBL in teaching Newton's laws, students' low motivation and insufficient time. Subsequently, the results showed an inadequate implementation level of GBL in teaching Physics. The findings also revealed a need for developing a training module that could assist teachers in designing educational games and implementing GBL in teaching Newton's laws. The requirements of the module were identified in this study.

Conclusion: The data obtained from this study will be used to design and develop an educational game design training module that meets the teachers' needs and thereby help them to create educational games and implement GBL better.

Keywords: Need analysis, game-based learning (GBL), educational games, training module, module development

1. INTRODUCTION

With the progression of Education 4.0, the World Economic Forum [1] has proposed a new educational approach known as playful learning. Within this framework, game-based learning (GBL) is employed as a technique that integrates games into lessons to enhance student engagement and enjoyment in the learning process. Connolly et al. [2] defined GBL as the utilisation of games within educational contexts with the purpose of achieving educational objectives. According to Shemran et al. [3], GBL fosters an interactive learning environment that effectively captures students' attention and motivation. Through GBL, students can visualise and engage with scenarios that may not be feasible in real-life settings. As a result, this immersive approach to learning enhances educational achievements and outcomes.

According to Guido [4], acquiring proficiency in Physics is of utmost importance as it contributes to the development of cognitive, scientific, and problem-solving skills. Apart from that, Tomara, Tselfes, and Gouscos[5] noted that classical mechanics, specifically Newton's laws, serves as the fundamental basis for all other branches of Physics.Therefore, it is essential to grasp concepts related to forces, motion, and Newton's laws before progressing to other areas within the field of Physics.

However, Physics is often perceived as a less captivating and unexciting subject when compared to Biology and Chemistry. As a consequence, students tend to lack enthusiasm for studying Physics [6, 7]. Furthermore, the topic of forces and motion in classical mechanics is widely regarded as the most challenging topic by a majority of teachers [8]. Many students frequently encounter difficulties in understanding formulas, interpreting definitions, and solving problems within this area [5, 9, 10, 11]. Consequently, they struggle to achieve the intended learning outcomes.

Earlier investigations have indicated that the integration of GBL in Physics education has yielded favorable outcomes in student learning. For example, Alias and Ibrahim [12] developed a game called 'The World of Newton' that immersed students in real-life scenarios relevant to Newton's laws, effectively facilitating their understanding. Similarly, Shute et al. [13] created 'Physics Playground,' a game that supported learning and enabled teachers to assess students' comprehension through game-based activities. Thunyaniti and Wuttiprom[14] also demonstrated the efficacy of card games in enhancing students' grasp of Physics motion. These GBL approaches have not only made the learning experience more enjoyable for students but have also fostered a positive attitude towards Physics. Furthermore, Cardinot and Fairfield [15] discovered that even a basic board game had the power to inspire and engage students, sparking their interest and involvement in the field of Physics, particularly in the study of astronomy.

Hence, Alias and Ibrahim [16] proposed using GBL to facilitate students' learning of Newton's laws of motion, where educators could develop educational games emphasising conceptual understanding and problem-solving abilities.Nevertheless, Kamışlı [17] highlighted that while educators are enthusiastic about integrating GBL into their teaching, many lack the knowledge and training to effectively incorporate it into their lessons.Avdiu[18] elaborated that integrating GBL in the classroom can present challenges for educators, particularly in terms of seamlessly incorporating it into the curriculum and effectively utilising the games. Similar difficulties were also observed by Denham, Mayben, and Boman [19].

Additionally, Hanghøj[20] has highlighted that previous studies on GBL have primarily focused on game characteristics, learning outcomes, and student-related factors, often neglecting the perspectives and experiences of teachers in educational gaming. According to Bell and Gresalfi[21] and Hung, Koh, and Jamaludin [22], teachers hold a crucial role in the educational process, as they are responsible for integrating various teaching and learning approaches in the classroom, whether they are innovative or traditional methods. In essence, teachers occupy a central position in the educational process, and their contributions are vital to its success.

Therefore, it is crucial to offer educators a training module that equips them with the skills to design educational games and successfully implement GBL in their classrooms, ultimately enhancing students' understanding of Newton's laws of motion. Moreover, assessing teachers' needs before designing training modules is imperative to identify appropriate solutions that address their current challenges.

A needs analysis is a systematic procedure that entails recognising the challenges faced by a specific group and exploring possible solutions to address those challenges, all while evaluating the requirements and demands of the population [23]. According to Nerita, Maizeli, and Afza[24], conducting a need analysis is a crucial initial step in developing a curriculum or course syllabus. Prior to creating any modules, it is essential to carry out a needs analysis to establish the specific specifications of the desired product [25]. Therefore, before proceeding with the development of the educational game design training module, it is crucial to identify the teachers' needs in order to create a practical and effective training module.

This research aimed to recognise the necessity of creating a training module for secondary school Physics teachers that focuses on designing educational games related to Newton's laws of motion. A need analysis study was conducted involving secondary schools Physics teachers in Malaysia to identify the challenges they encountered in teaching Newtonian concepts.Furthermore, the study aimed to determine the requirements for module development and professional training on the GBL approach and assess the current implementation level of GBL in Physics instruction. Additionally, the study included an analysis of the users' needs to meet the educational requirements of secondary school Physics teachers effectively.

2. METHODOLOGY

2.1 Research Design

This research utilised a quantitative methodology, employing a survey to gather input from Physics teachers in secondary schools regarding the challenges they encountered when teaching Newton's laws of motion and determine the necessity of creating a training module for educational game design. The Discrepancy model was employed to assess the needs. Before distributing the questionnaire to participants, a pilot test was conducted to ensure the reliability of the survey instrument.

2.2Respondents

This research involved 338 Physics teachers from secondary schools in Malaysia. The study employed a stratified sampling technique by specifically selecting teachers whose students encountered challenges in understanding Newton's laws of motion. This selection process was done using Part 2 of the need analysis survey. If the participants' students did not face difficulties in learning Newton's laws, they would be automatically excluded from further participation in the survey.Participation in the study was voluntary, and all survey respondents provided their consent digitally after being fully informed about the research.

2.3Research Instrument

This research utilised an online survey, employing Google Forms to create a questionnaire for needs analysis. The questionnaire items were derived from previous surveys conducted by Kiong et al. [26], Kamışlı [17], Fratiwi et al. [27], and Aykutlu et al. [8]. The questionnaire encompassed five sections, namely: (i) Demographic information, (ii) Challenges encountered while teaching Physics, (iii) Implementation of GBL in Physics classrooms, (iv)

Necessity for professional development regarding the GBL approach, and (v) Content requirements for modules.

Section 2, Section 4, and Section 5 of the survey adopted a 5-point Likert scale format, where respondents could choose from options ranging from 1 (strongly disagree) to 5 (strongly agree). The decision to use a 5-point Likert scale was based on its advantages, as it can enhance the response rate, minimise respondent frustration, and reduce the likelihood of missing data [28, 29]. On the other hand, Section 3 was presented as a close-ended survey format.

The questionnaire underwent a thorough review and validation process conducted by five experts: two specialists in GBL, one expert in Physics Education, a Master Teacher of Physics and an English language expert. Following this, a pilot test was carried out involving 41 Physics teachers from secondary schools who were not part of the actual study. The purpose of the pilot test was to assess the reliability of each construct in the questionnaire. It is important to note that the respondent's participation in the pilot test was voluntary.

Table 1 displays Cronbach's alpha value for each construct presented in the need analysis questionnaire.

Table 1. Constructs in the need analysis questionnaire with Cronbach's alpha values

No.	Constructs	Cronbach's alpha value
1.	Challenges faced while teaching Physics	0.863
2.	Implementation of GBL in Physics classrooms	0.859
3.	Need for professional development for the GBL approach	0.896
4.	Requirements of module content	0.924

Gliem and Gliem[30] stated that Cronbach's alpha could range between 0.00 and 1.00, with a higher value indicating greater internal consistency of the instrument. Referring to Table 1, all of the constructs' items exhibit high reliability, as indicated by Cronbach's alpha values exceeding 0.8. This implies that each item in the questionnaire demonstrates a strong correlation.

2.4Data Collection and Analysis

Respondents received the need analysis questionnaire through their official school emails, and data collection took place forthree months. The collected data was then analysed using SPSS version 22 software. The data analysis primarily focused on descriptive measures such as percentages, means, and standard deviations. The mean values of the items in Sections 2 to 5 were interpreted based on the mean interpretation scales proposed by Nunnally and Bernstein [31], which are presented in Table 2.

Table 2. Mean interpretation value

Mean score	Interpretations
1.00 – 2.00	Low
2.01 – 3.00	Average
3.01 – 4.00	High average
4.01 – 5.00	High

Source: Nunnally and Bernstein [31]

3. RESULTS

The demographic information of the participants is presented in Table 3, which reveals that out of the total sample of 338 teachers, 95 were male, and 243 were female. More than half of the respondents (50.6%) fell within the age group of 31-40 years old, while 32.3% were between 41-50 years old. Additionally, 12.1% belonged to the age range of 51-60 years old, and only 5.0% were in the age group of 21-30 years old. The participants in the study represent various states across Malaysia.

Table 3. Demographic information (*n* = 338)

Variables	Frequency (percentage)
Gender	
Male	95 (28.1)
Female	243 (71.9)
Age	
21 – 30	17 (5.0)
31 – 40	171 (50.6)
41 – 50	109 (32.3)
51 – 60	41 (12.1)

Table 4 illustrates the challenges encountered by teachers when teaching Newton's laws of motion. The findings indicate a strong consensus among respondents regarding the lack of experience utilising the GBL approach for teaching Newton's laws of motion as a significant challenge (mean = 4.15), followed by students' low motivation in learning Newton's laws, which also received a high average rating (mean = 4.05). Another significant challenge highlighted by the participants is the insufficient allocated time for teaching Newton's laws of motion (mean = 3.96), which garnered a substantial level of agreement.

Table 4. Challenges encountered while teaching Newton's laws of motion

No.	Item/ Statements	Mean (SD)	Level
1.	Students' low motivation in learning Newton's laws of motion	4.05 (0.961)	High
2.	Insufficient number of hours allocated for teaching Newton's laws of motion	3.96 (0.922)	High average
3.	Lack of experience teaching Newton's laws of motion using the GBL approach	4.15 (0.829)	High

Meanwhile, Table 5 presents the extent to which theGBL approach has been implemented in teaching Physics among the respondents. Table 5 clearly indicates that only a minority of participants, comprising 30.2% of the sample, have engaged in the creation of educational games. Within this group, 10.4% have developed both digital and non-digital games, 11.5% have focused on non-digital games, and 8.3% have concentrated on digital games. In contrast, most respondents (69.8%) have not created any educational games, whether digital or non-digital, for Physics instruction. Similarly, only 29.9% of the participants have effectively utilised the games they developed in teaching Physics. Notably, most participants (70.1%) have never incorporated the games they created into their Physics teaching practices.

Apart from that, Table 5 highlights the primary reasons provided by respondents for not utilisingthe GBL approach or educational games in Physics instruction. As indicated by 44.7% of participants, the most prevalent reason is the inadequate technical infrastructure in schools. Other reasons cited include feeling inadequate or lacking skills in this area (21.3%) and time constraints (19.5%). A small percentage of teachers (5.6%) expressed disapproval towards GBL, gamification, and educational games in Physics teaching. Additionally, 8.9% of teachers offered explanations for not implementing GBL in Physics instruction. Among the 30 respondents, 12 stated they lacked the necessary skills to design games or integrate GBL into their teaching, citing reasons such as lack of expertise, creativity, ideas, knowledge, and resources. Eight respondents expressed doubts about the effectiveness of GBL, suggesting that students prefer traditional teaching methods, struggle to connect concepts after playing games and question whether GBL can effectively achieve learning objectives. The remaining ten reasons were associated with time constraints, with respondents stating that they were overwhelmed with schoolwork, unable to cover the syllabus, or found GBL too time-consuming and unproductive.

Table 5. The implementation of the GBL approach in Physics classrooms

Item	Frequency (percentage)	
Development of own educational games		
Digital games	28	(8.3)
Non-digital	39	(11.5)
Both digital and non-digital	35	(10.4)
None	236	(69.8)
Using own developed educational games successfully in lessons to teach Physics		
Yes	101	(29.9)
No	237	(70.1)
Reasons for not using educational activities such as game-based learning, gamification and educational games in teaching Physics		
Feeling of incompetence	72	(21.3)
Lack of adequate technical infrastructure in schools	151	(44.7)
Time constraints	66	(19.5)
Disapproval of these approaches	19	(5.6)
Others	30	(8.9)

Subsequently, Table 6 highlights the substantial demand for professional development in GBL, specifically for teaching Newton's laws of motion. The respondents strongly agreed on the necessity of such training, as evidenced by a mean value of 4.45. Furthermore, the participants emphasised the need for a comprehensive training module to assist them in designing educational games and effectively integrating the GBL approach into their instruction of Newton's laws (mean value = 4.61).

Table 6. Needs of professional development for game-based learning (GBL) approach in teaching and learning Newton's laws of motion

No.	Item/ Statements	Mean (SD)	Level
1.	There is a need for professional development in the GBL approach to teaching Physics (Newton's laws of motion).	4.45 (0.630)	High
2.	There is a need to construct a game design training module to	4.61	High

	guide teachers in designing their educational games and integrate the GBL approach to teach Newton's laws of motion.	(0.578)

Table 7 provides an overview of the specific content requirements identified by the surveyed teachers for the training module. The most highly ranked requirement, with a mean value of 4.53, was the inclusion of readily available educational games that could assist students in mastering the necessary knowledge and enhance their interest in learning about Newton's laws of motion. Additionally, the teachers expressed a desire for the games to have easy-to-understand guidelines and clear instructions, which received a mean value of 4.52. The third highest-ranked requirement, with a mean value of 4.40, pertained to providing appropriate resources and materials for implementing GBL or gamification approaches in teaching and learning about Newton's laws of motion.

Furthermore, there is a need for the training module to offer explanations on GBL and gamification techniques, as indicated by a mean value of 4.15. Another essential requirement is including a step-by-step guide for designing educational games, along with a specific example showcasing the development process for Newton's laws of motion. This requirement also received a mean value of 4.12.

The mean values for having a guide for time allocation in implementing the GBL or gamification approach in teaching Newton's laws of motion and the steps involved in implementing the GBL approach were found to be the lowest, with values of 3.92 and 3.87, respectively. However, these values still indicate significant agreement regarding these two requirements.

Table 7. Requirements of module contents

No.	Item/ Statements	Mean (SD)	Level
1.	Contain a description of GBL and gamification approach	4.15 (0.820)	High
2.	Have appropriate resources and materials to take on the GBL or gamification approach for teaching and learning Newton's laws of motion.	4.40 (0.679)	High
3.	Consists of readily available educational games that can assist students in mastering necessary knowledge and enhance their learning interest towards Newton's laws of motion.	4.53 (0.640)	High
4.	With easy-to-understand game guidelines and clear instructions.	4.52 (0.612)	High
5.	Have a guide for time allocation in implementing the GBL/ gamification approach in teaching Newton's laws of motion.	3.92 (1.014)	High average
6.	Equipped with steps on how to design educational games for Newton's laws of motion based on students' needs.	4.12 (0.782)	High
7.	Contain steps in implementing the GBL approach in teaching Newton's laws of motion.	3.87 (0.990)	High average
8.	Have a clear example of work steps in developing an educational game for Newton's laws of motion.	4.12 (0.820)	High

4. DISCUSSION

The need analysis conducted to evaluate the requirements of secondary school Physics teachers in teaching Newton's laws of motion yielded valuable insights. The findings revealed that a prominent challenge teachers facedwas the lack of experience in utilising the GBL approach when teaching Newton's laws of motion. Consequently, this challenge hampers their ability to employ a more innovative and engaging pedagogy, namely the GBL approach, in their instruction of Newton's laws. As a result, they struggle to capture students' interest and motivation in learning the topic, which represents the second challenge. Additionally, teachers encounter the issue of inadequate instructional time allocated for teaching Newton's laws. The time constraint further complicates the implementation of GBL, as it requires teachers to invest a substantial amount of time and effort.

Furthermore, the findings reveal that Physics teachers in Malaysia possess limited proficiency in designing educational games. A significant number of respondents indicated that they have never created or designed any educational games for Physics, regardless of whether they were digital or non-digital. Moreover, a majority of respondents acknowledged that they had not successfully implemented the games they created for teaching Physics. Concurrently, most participants reported a lack of knowledge and skills required to integrate GBL into their classroom practices effectively. These findings suggest that the adoption of GBL in Physics instruction is not yet widespread among secondary school Physics teachers in Malaysia. It indicates that these teachers are more accustomed to traditional teaching methods and have yet to fully embrace new teaching and learning strategies. This finding is consistent with the study by Kaimara et al. [32], which identified a preference for traditional teaching methods as one of the barriers to incorporating GBL in the classroom.

This finding aligns with the results of previous studies conducted by Allsop and Jessel[33] and Avdiu[18], which explored the challenges faced by educators in England, Italy, and Austria. These studies also identified a lack of knowledge, skills, and experience in game design and the integration of GBL into lessons. When teachers feel uncertain about incorporating GBL due to their limited knowledge and skills, it indicates a need for adequate professional development and training opportunities [34, 35, 36]. Consequently, most respondents in this study emphasised the importance of receiving professional development in game design, GBL training, and a dedicated training module to support the creation of educational games for Physics.

Due to the time constraints faced by the respondents in creating captivating and interactive teaching materials, they expressed a desire for a training module that provided ready-made educational games. These games would assist students in acquiring essential knowledge and foster their enthusiasm for learning about Newton's laws of motion. The findings strongly emphasise the need to develop a dedicated training module geared explicitly towards designing educational games for teaching Newton's laws of motion.

Most participants recognised the importance of the training module in promoting GBL, integrating it into the instruction of Newton's laws, and improving their game design skills. In addition, Ali and Mahamod[37]emphasised the importance of developing a module that considers the existing challenges and addresses the target audience's specific needs. This ensures that the resulting module effectively fulfils the requirements of its intended users.
Consequently, the findings from the need analysis will serve as the foundation for designing and developing the content of the training module in the subsequent phase. The training module will be tailored to address the teachers' identified needs. By including readily-available educational games, materials, and resources, the module aims to enhance teachers' understanding and utilisation of GBL in teaching Newton's laws of motion. As a result, this will encourage teachers to embrace GBL as an instructional approach to teach Physics and foster improved student learning outcomes and motivation, particularly in the context of Newton's laws of motion.

5. CONCLUSION, LIMITATIONS AND SUGGESTIONS

The study has identified the need for developing an educational game design training module and the challenges teachers faced in teaching Newton's laws and implementing GBL in Physics instruction. The results indicate significant obstacles in GBL implementation and game design due to insufficient professional development opportunities, infrastructure and technical support, and time constraints. Consequently, the implications of this study emphasise the importance of developing a high-quality module that addresses these challenges and supports teachers in designing educational games and integrating GBL into their Physics instruction, particularly for teaching Newton's laws of motion. Such a module, tailored to meet the needs and address the problems teachers face, can help alleviate their difficulties and enhance student learning and motivation concerning Newton's laws. Conducting a need analysis is essential in gathering information about the challenges the target population faces and determining the content and specifications required for module development. However, it is worth noting that this need analysis primarily relied on quantitative survey research, which limited the depth of insights into the challenges encountered in teaching Newton's laws and the barriers that hinder the integration of GBL in Physics instruction. Therefore, conducting further in-depth research using qualitative research methods could explore the challenges faced and provide a more comprehensive understanding of the barriers to incorporating GBL in Physics teaching.

CONSENT

All the authors declare that digital informed consent was obtained from all the participants. Participation in this study was voluntary. A copy of the digital informed consent is available for review by this journal's Editorial office/Chief Editor/Editorial Board members.

ETHICAL APPROVAL

All authors with this declare that this study is approved by the appropriate ethics committee of Sultan Idris Education University, Malaysia, with the reference number 2021-0214-01.

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