www.ijses.net

Efficacy of a Special Relativity Game-Based Learning Tool

John Rey Busime
Carlos Hilado Memorial State University, Philippines

Vincent Algarme
Carlos Hilado Memorial State University, Philippines

Joeylene Bene
Carlos Hilado Memorial State University, Philippines

John Lester Polines
Carlos Hilado Memorial State University, Philippines

Faith Celeste Ole
Carlos Hilado Memorial State University, Philippines

To cite this article:

Busime, J.R., Algarme, V., Bene, J., Polines, J.L., & Ole, F.C. (2025). Efficacy of a special relativity game-based learning tool. *International Journal of Studies in Education and Science (IJSES), 6*(4), 355-369. https://doi.org/10.46328/ijses.5491

International Journal of Studies in Education and Science
2025, Vol. 6, No. 4, 355-369 https://doi.org/10.46328/ijses.5491

Efficacy of a Special Relativity Game-Based Learning Tool

John Rey Busime, Vincent Algarme, Joeylene Bene, John Lester Polines, Faith Celeste Ole

Article Info

Article History

Received:
22 March 2025
Accepted:
20 August 2025

Keywords

Special theory of relativity
Physics education
Game-based learning
Mixed method

Abstract

Teaching modern physics, particularly special theory of relativity (STR), is challenging because of its abstract nature which requires thought experiments. This mixed-methods study was designed, developed and assessed a Special Relativity Game of Games (SRGoG) to overcome such challenges and enhance learning. Guided by a Plan-Do-Check-Act (PDCA) framework, and a convenience sampling technique, several students and teachers from a state university evaluated the game-based learning (GBL) tool's efficacy. Quantitative data indicated the game to be v*ery acceptable* for both its content validity (M = 4.85, *SD* = 0.35) and instructional and technical quality (M = 4.81, SD = 0.42). Qualitative findings, have also shown valuable feedback implying its student-centered characteristics such as educational, easy-to-use, user-friendly, and engaging. These results suggest the potential use of the board game for instructional purposes.

Introduction

Einstein's revolutionary contribution to science, which gave birth to modern physics, paved the way for the foundation of modern technology. His special theory of relativity (STR) transformed the way physicists look at the world, which is a prototypical example of a theory in physics (Kamphorst et al., 2021). This, in effect, has undeniably impacted the development of technology. However, the stigma of studying physics, known for its complex math and abstract concepts, may demotivate learners to appreciate its relevance if students' enthusiasm decreases over time (Kapanadze et al., 2023). One possible factor that may affect their disinterest is if they do not comprehend the nature, advantages, beauty, and work of learning physics (Assem et al., 2023). That is why teachers' roles as innovators must be creative in successfully implementing science education (Cortes et al., 2024). There is a need for effective assessment methods to measure learners' understanding, especially given students' limited preparation in mathematics and physics (Wan Ariffin et al., 2024).

One method that enhances learning effectiveness and allows tailored teaching and feedback for students is Game-based learning (Burmich et al., 2023). Game-based learning (GBL) is a learning theory that incorporates concepts and applications of games to improve learner participation and comprehension (Toscano de Brito Júnior et al., 2023). According to Amado and Roleda (2019), using games for instruction that are fun, exciting, and interesting fosters cooperation and healthy competition among the students. When considered by educators, these aspects could ensure effective and efficient learning for students. Kacmaz and Dub'e (2022) denoted that GBL has the potential to improve learning and instruction, for it has been widely supported as a pedagogical tool.

Consequently, many studies have focused on digital games influenced by the ever-changing technological landscapes, also known as Digital Game-Based Learning (DGBL) (Grande-de-Prado et al., 2025; Haleem et al., 2022; Khuda et al., 2022; Zheng et al., 2024). These expanding virtual worlds have become the social norms, affecting the educational landscape over the past decades (Wenzel et al., 2025; Zheng et al., 2024), reinforcing the United Nations' Sustainable Development Goals (SDG 4) for quality of education accessible to all. Though DGBL has significantly affected students' academic performance and engagement, their excessive exposure to screen time may harm their cognitive, linguistic, and social-emotional growth (Muppalla et al., 2023). Students of today's generation, having been born into an ever-changing digital ecosystem augmented by mobile media, or known as "digital natives," are indeed exposed to these strategies to enrich their learning. Even if the equitable use of Artificial Intelligence (AI) and technology has numerous advantages, physical and mental health are other aspects of health concerns that need to be confronted globally, with symptoms of mental distress more prevalent now than before the COVID-19 pandemic (OECD, 2025). Physical games essential for cognitive and social development may be reciprocated by non-physical interactions, eventually leading to serious adverse effects on students' health over time (Adipat et al, 2021).

In the Philippines, Republic Act No. 12080, also known as the "Basic Education Mental Health and Well-Being Promotion Act," has been crafted to support learners' mental health (Second Congressional Commission on Education, 2024). Anchoring on this logic, promoting physical activities, especially in science education, is vital to limit the effects of prolonged screen time on students' physical and mental health (Qi et al., 2023). According to Cortes et al. (2024), one of the perennial problems in the Philippines that may hinder the delivery of a sustainable and proper science education is the lack of opportunities for hands-on activities. These tangible objects that allow students to interact with others foster a more immersive experience (Mora et al., 2021), essential for learning.

In this context, a game-based activity in STR focusing on diminishing exposure to screen time among young individuals was conceptualized. A GBL employing real hands-on experiences inspired by classical games should be revived and augmented inside the classroom. Unfortunately, little research has been conducted on these fundamental concepts of Einstein's theory in a game-based approach (Alstein et al., 2021). As future educators, teaching modern physics, particularly STR, is challenging because of its abstract nature and concepts (Leonardi et al., 2022). This introductory topic in the contemporary physics class, which utilizes thought experiments, has gained international interest and has been found to have a shortage of empirical evaluation of learning outcomes (Alstein et al., 2021). Towards this vein, a notion prompted the researchers to create a board game to test and enhance students' understanding of STR terms and concepts. This study aspired to assess the impact of the developed board game and how it may work efficiently for classroom use.

Research Questions

Generally, this study aims to design, develop, and evaluate a GBL material for Einstein's STR. It specifically seeks to answer the questions:

1. What could be designed and developed as a GBL material in special relativity?

2. What is the quality of the developed GBL material in terms of content, instruction, and technicalities?

Method

Research Design and Environment

This study follows a mixed-methods research approach that integrates quantitative and qualitative methods to generate a more complete understanding than a single method. Mixed methods research is particularly suited to complex fields such as education, where multiple perspectives and levels must be considered simultaneously to understand learning and instruction (Mejeh et al., 2023). The initial stage entailed collecting and analyzing quantitative data and accumulating and interpreting qualitative data to enrich findings. The design offered numerical assessments and a qualitative analysis of the board game evaluation introduced for special relativity instruction.

Furthermore, this study was conducted during the second semester of the academic year 2024–2025 in one of the state colleges and universities (SUCs) of Negros Island Region. This institution, which offers secondary education courses, particularly Science as its specialization, is located near the western area of the Visayas region in the Philippines. Specifically, data was gathered during the University Week celebration last May. This environment of celebration encouraged science enthusiasts to explore the physics world of Einstein's contributions. Several outputs from different groups of third-year college students majoring in science, and taking a modern physics class, were displayed inside the venue.

Research Participants

The participants were individuals from diverse educational backgrounds, including science teachers and students taking a Bachelor of Secondary Education major in Science (BSEd Science) and a Bachelor of Science in Applied Mathematics (BSAM). These courses have modern physics subjects, enabling students to be knowledgeable about the topics of relativity.

Of the 30 participants, 12 were male, consisting of 4 science teachers and 8 students, while the remaining 18 participants were female. Among the science teachers, two had at least master's degrees in general science and environmental engineering, respectively, while the other two had doctorate degrees in science education. Meanwhile, most of the students who actively participated in the evaluation belonged to the science education majors (n = 18), and a few (n = 8) from a small group course of applied mathematics. These participants, a combination of teachers and learners, ensure the well-roundedness of the evaluation. Through a convenience sampling technique, all data from respondents were gathered according to their accessibility and availability to the researchers. Since this was done during a university-wide activity, the number of respondents may have been affected due to limited time and other factors, such as there were other groups presenting their developed tools inside the venue, too. It could be noted that the learning environment was where the participants could walk in and participate freely in the game-based learning experience. This setting enabled an accurate classroom implementation simulation, allowing the game's integrated naturalness to facilitate a learning session on special

relativity.

Research Instruments

The developed game-based instructional material called "Special Relativity Game of Games" (SRGoG) utilized an adapted research questionnaire from Jeong (2024). Although a separate statistical reliability was not established in this study, the face validity of the instrument was done by a physics teacher with significant physics research experience and a doctorate degree in physics education. Criterion A contained questions that regarded content validity, focusing on the game's content alignment with the learning competencies and curricular expectations. Criteria B, on the other hand, evaluated the instructional and technical aspects, focusing on the game's functionality, ease of use, attractiveness, level of interest it generates in the users, and encouragement in using thinking skills. The first two sets employed a five-point Likert scale, denoting 5 as "Very Acceptable" to 1 as "Not Acceptable". Finally, criterion C contained the three open-ended questions tailored to capture participants' qualitative responses about their experience and recommendations for improving the developed game tool.

The SRGoG was designed as an educational board game aimed at assisting students to learn and understand Einstein's Special Theory of Relativity. Adapting some of the mechanics from classical games, like snake and ladders, tic-tac-toe, and name or goal game, this GBL activity simplifies abstract concepts like time dilation, length contraction, and relative motion through interactive gameplay. This board game features a friendly and competitive learning experience while providing proper integration of learning and evaluation. The intentional balance of play and teaching makes the Special Relativity Game of Games unique. This game sustains learners' attention and encourages peer-to-peer interaction and collaboration.

Data Procedures

The data gathering procedure for this research study was carefully designed to assess both the effectiveness and quality of the instructional board game. Guided by the PDCA cycle, the SRGoG was planned, developed, evaluated, and analyzed accordingly.

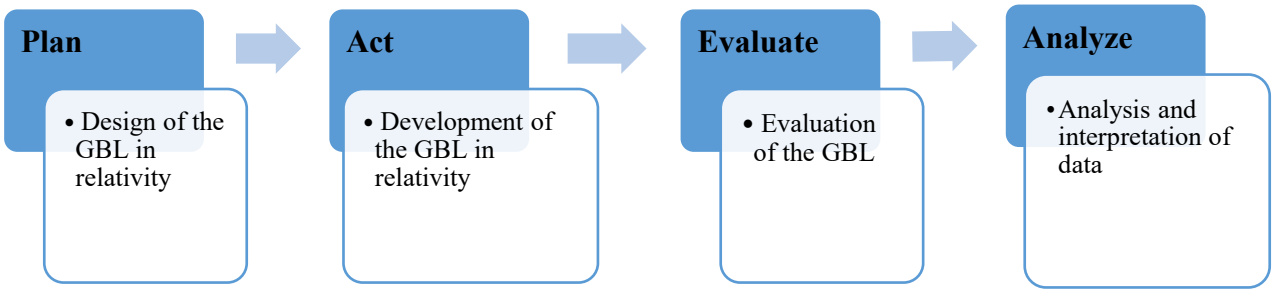

Figure 1. Phases of the Study

Adapting the Plan-Do-Check-Act (PDCA) cycle that emphasizes continuous improvement, this study used a schematic framework that involves planning or designing (*Plan*), acting (*Do*), evaluating (*Evaluate*), and

reflecting on or analyzing (*Act)* the data acquired (Nguyen et al., 2023).

After identifying the scarcity of GBL in relativity, one of its goals is to create an alternative approach to these abstract topics. Hence, the planning aspect delved into conceptualizing the game and considering Einstein's relativity as its content focus. The "do" stage, which was set to be the acting phase, facilitated the development of the designed game. Carrying out the ideas from the plan, from what type of materials were to be used or the set of mechanics and procedures of the game, could lead to a series of tests that would eventually be used for the next phase – the evaluation. In this "check" stage of the PDCA cycle, the implementation of the game board served as the evaluation section. Utilizing a questionnaire that would assess the quality of the game board is crucial. Any quantitative or qualitative feedback would then be analyzed for interpretation – the analysis phase. Reflecting on the data gathered is essential. This is the process of using the learning from the check phase to take action, either implementing the change or devising the plan.

All the participants engaged in the discussion of the mechanics of the board game and were provided with equal opportunities to access or play the SRGoG. Students and teachers used the learning material directly, while researchers offered instructional oversight. The selection process led to the practical evaluation of the board game's instructional value and usability, which was ensured by diversity in academic background.

This structure enabled the study to capture the holistic views of teachers and learners, giving a balanced view of the educational impact of the board game. The variation in the respondents helped derive practical insights regarding the game's instructional design, technical quality, user experience, and suitability for use in classrooms. The presence of teachers provided professional analysis, while the students' feedback captured end-user interest and learning.

Data Analysis

The study explored both quantitative and qualitative analyses. Quantitative data collected through the adapted research instrument assessed the Special Relativity board game's content, instructional, and technical value. The participants rated the game using a Likert scale, and the findings were examined by computing the mean and standard deviation of the ratings for each instrument category. The mean scores and standard deviation of Part A (Content Validity) and Part B (Instructional and Technical Quality) were calculated using Microsoft Excel. The researchers computed the mean to establish the level of acceptability of the game's content, instruction, and technical features based on the provided assessments. The standard deviation was computed to determine the responses' uniformity or lack of consistency. These measures gave participants an accurate summary of the material's performance regarding content alignment, design, and quality structural features.

For the qualitative analysis, responses to the open-ended questions were analyzed through thematic analysis to find recurring themes and main findings. The researchers used thematic analysis to interpret and analyze the data obtained in the survey. This meant extracting and managing the pieces of feedback, including narratives, educational insights from the game, and constructive comments for improvements. Thematic analysis was

employed because it is suitable for open-ended responses and captures recurring themes in the respondents' answers. This approach added supporting qualitative information to the already existing quantitative data. The combination of descriptive statistics and thematic analysis allowed the researchers to evaluate the instructional material from a quantitative and qualitative perspective.

Ethical Considerations

The researcher addressed the general principles of respect for persons, beneficence, and justice to ensure the ethical soundness of the study. These principles include social value, consent, the vulnerability of the research participants, risk and benefits, privacy, and confidentiality. Each participant had given their consent to be a part of this study. The participants were oriented about the purpose and procedure of the study. The respondents' participation was voluntary, and they had the right to withdraw if they felt uncomfortable during the data-gathering process. To address this, in each interview, the researchers gave time for the participants to freely share only the experiences they are emotionally and psychologically comfortable sharing. The participants were assured of utmost confidentiality regarding whatever information they shared.

Moreover, their identities were kept hidden under pseudonyms in adherence to the Data Privacy Act of 2012. The researchers also disclosed that there would be no monetary benefits and declared no conflict of interest in conducting this study.

Results and Discussion

This section, rooted in the PDCA framework, discloses the quantitative and qualitative findings of the study. It also seeks to address the research problems by outlining them using the plan, act, evaluate, and analyze approach. Specifically, the plan and act phases facilitated answering research problem 1, while the succeeding phases (evaluate and analyze) answered research problem 2. Since the framework follows continuous improvement, each phase, inevitably underwent significant changes for improvement, leading to the current status of SRGoG.

Plan Phase

In this phase, conceptualizing the game-based learning material in the special theory of relativity was established. Different board games, such as Snakes and Ladders, Tic Tac Toe, The Name Game, and Goal Game, inspired the design. The Name Game, which aimed players to respond to prompts with names starting with specific letters; Tic-Tac-Toe, which combined strategy with content mastery; The Goal Game, which required the players' plastic disks to reach the opponents' side by finger flicking, and the main board was inspired by Snakes and Ladders.

These games were combined to promote fun learning experiences to students; thus, the game board is called the Special Relativity Game of Games (SRGoG). One of the purposes of this playboard is to test and review the conceptual understanding of STR terms and concepts (e.g., time dilation, simultaneity, length contraction, and many more). It could also be an avenue to strengthen their existing knowledge and basic cognitive skills. Likewise,

to assist teachers in making learning fun and enjoyable, this SRGoG could be employed as a pretest or posttest activity, an ice breaker, or simple motivational tasks by teachers.

Act Phase

After careful planning of the game, its development began. The game's mechanics were carefully thought out, adapting the rules of other games that were played before, but with twists on some of their procedures. Thus, the SRGoG was constructed using recyclable materials.

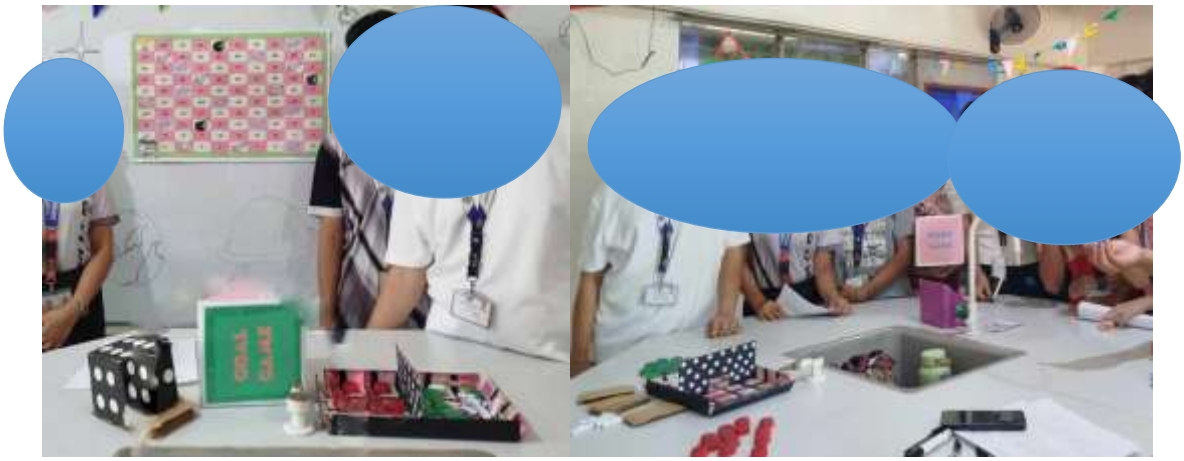

Figure 2. The Researchers with the Actual Sizes of Components (left) and Some of the Participants who Played the SRGoG (right)

In order to fully understand the mechanics of the game, several components were needed for familiarization, which could be summarized and described in Table 1. Upon rolling the dice and subsequently moving it around the board, participants needed to win one of three featured mini-games first: *The Name Game*, which has players responding to prompts with names starting with specific letters; *Tic-Tac-Toe,* which combines strategy with content mastery; and *The Goal Game*, which demands the players' plastic disk to reach the opponents' side. Each mini-game was designed to engage various cognitive and motor skills while reinforcing special relativity concepts. After winning a mini-game, players roll a die to move forward on the board. Along the way, they would encounter many kinds of tiles, including a Question Tile that assessed their knowledge of Special Relativity and Bomb Tiles, which moved them backward as a penalty for incorrect answers or unfortunate landings.

Table 1. Components of the SRGoG

Components	Actual Images
Main board: A board with different tiles, including regular movement spaces, "question" tiles (tiles with galaxy/rocket icon), and "bomb" tiles (if players land in these tiles they need to move backward).	

Components	Actual Images
Standard Dice (left): A standard six-sided dice used to determine movement. Mini game dice (right): Dice that will decide what mini game will be played.	 
Question Cards: Cards containing questions related to Special Relativity concepts (time dilation, length contraction, relative velocity, etc.). These cards have different difficulty levels and will be used when a player lands on question tiles.	
Name Game: A fast-paced word game where players must answer a question using letters from a set of provided letters and spell out the correct answer, usually seen at the top of bottle cap. Players will take turns providing the letters that comprise the answer, the last player to provide a correct letter wins and will have the chance to roll the standard dice. Tic-Tac-Toe: A classic game of strategy, where players need to align the same colors that symbolize their team. It can be horizontally, vertically, or diagonally. Goal Game**:** A game where players need to use the garter to slide their colored caps to the opponent's side. The first one to do so, wins.	

Evaluate Phase

This section examines the quality of the SRGoG in terms of content, instruction, and technical aspects. Any collected quantitative and qualitative data will be presented hereafter to give glimpses of its evaluation based on its prescribed scale indicator. According to Jeong (2024), the model's acceptability could be interpreted as shown in Table 2.

Table 2. Ranges for Interpretation

Mean Score Ranges	Interpretation
1.00 – 1.80	Not Acceptable
1.81 – 2.60	Fairly Acceptable
2.61 – 3.40	Moderately Acceptable
3.41 – 4.20	Acceptable
4.21 – 5.00	Very Acceptable

Based on the findings, Table 3 shows the corresponding values and interpretation of the data gathered from the respondents.

Table 3. Descriptive Statistics of the SRGoG

Criteria	**Mean**	**SD**	**Interpretation**
Content	4.85	0.35	Very Acceptable
Instructional and Technical Quality	4.81	0.42	

It can be found that the board game was *very acceptable* in all aspects. This could mean it adheres to a positive content quality and implies that the learning tool's content aligns with the learning competencies and curricular expectations.

Likewise, similar findings could be exhibited in terms of the instructional and technical features of the tool, signifying its *very acceptable* and functional nature in affecting affirmative learning. This also suggests that the game had a positive impact in terms of its ease of use, attractiveness, level of interest it generates in the users, and encouragement to use thinking skills.

Furthermore, qualitative data from the open-ended questions of the questionnaire also showed positive responses from the teachers and students. The following themes emerged in the remarks amongst the participants, which could be summarized in Table 4.

Table 4. Theme and Subthemes of Collected Data

Theme/subthemes	Number of comments	Description
Theme: Student-centered learning approach		This theme emphasizes how the SRGoG worked effectively in enhancing their knowledge. It underscores its student-centered approach and user-friendly design that engages students to learn with ease and fun.
• Subtheme 1: Educational context	18	
• Subtheme 2: Ease of use	17	
• Subtheme 3: Fun and exciting	15	

Overall, the SRGoG was *acceptable* to the students and teachers, exhibiting a student-centered learning approach. They conveyed that the game board is educational, easy to manipulate, and exciting to play. According to their feedback, the board game improved their understanding of the concepts. To wit, *(Note: R-1 stands for Respondent 1, and so on)*

> *"It improved my perspective about Einstein's theory, because there's a lot of information."* (R-1)
> *"It is great, because it is very educational and like a game of questioning."* (R-2)
> *"It was good and has many surprises and elements, but also has great educational information that it can impart."* (R-3)

Respondents 4, 5, and 6, also emphasized the insightful and educational contributions based on the following extracts:

> "*It is effective in a way that gives you insights about the topic."*
> *"There is learning when you play the games that is very intellectual and fun."*
> "*The model provided a hands-on approach to learning physics concepts that are often difficult to learn."*

Moreover, other common themes gathered from their feedback centered on the ease of use and fun-filled experience of the users. Based on the following extracts, respondents collectively remarked on how it was easy, exciting, and engaging the game board was. To wit,

> *"It is efficient and easy to utilize as the concept is readily familiar to learners."* (R-7)
> *"It is very easy to use, and it was explained clearly on how to use or to play the learning activity."* (R-8)
> *"It worked well, it is a nice model for the students and makes the lesson easier to understand."* (R-9)
> *"It is very fun and interactive, and it is easy to manipulate."* (R-10)
> *"The board game activity brings excitement as I learn the concept of physics (Relativity)."* (R-11)

Analyze Phase

In this stage, the interpretation of the findings in the preceding section will be discussed explicitly, citing related literature or studies that could support the outcomes of this study. Based on the statistical results of Table 3, all criteria indicated by the tool showed positive measures, implying a valuable impact on learning the STR topics. Data suggests how the developed game board aligned with the contents and objectives needed in the curriculum. An effective game-based learning material must have a balance between theoretical content and learning competencies (Adipat et al., 2021), and as attested by the quantitative findings, SRGoG may have attained this perspective. The low standard deviation value (SD = 0.35) suggests its consistency or homogeneity of data, signifying uniform agreement from the respondents.

Despite the ambiguity of game-based learning due to the variety of formats and contexts (Byusa et al., 2022), it

cannot be denied that these educational games not only enhance students' conceptual understanding but also motivate them to learn and make sense of the learned content. It has been manifested from other studies that employing board games that have been well-accepted by learners could become effective resources for teaching physics in an educational setting (Janiga & Haverlíková, 2024). Lasala (2023) pointed out that teachers who use teaching methods that could help students become critical thinkers, like innovative strategies, may significantly improve their learning. A positive acceptability of board games for teaching physics content in a classroom setting increases student interest in physics and improves student and teacher peer relationships during discussion (Akimkhanova et al., 2023). This corresponds to a constructivist method of letting students understand the contents through hands-on and mind-on tasks (Byusa et al., 2022), initiating cooperative learning amongst learners.

Furthermore, a well-designed board game with a *very acceptable* instructional and technical quality could provide multi-level interactions like behavioural, cognitive, and affective engagements, leading to increased interest and competence (Machuqueiro & Piedade, 2024; Kacmaz & Dub´e, 2022; Rajkovic et al., 2019). As observed in Table 3, the high acceptability (M = 4.81) and agreement (*SD* = 0.42) of the respondents to the SRGoG indicates the board game's effectiveness in teaching them a clear, well-produced, and functional learning material. Board games with strong instructional quality provide sensory and imaginative immersion (Tsarava et al., 2018) that may allow players to absorb knowledge unconsciously while playing (Paz-Garcia et al., 2022). Therefore, it is crucial that instructional materials that incorporate thought experiments must be employed to bridge the gap between theoretical knowledge and practical understanding, particularly for non-experimental concepts in physics (D'Abramo, 2023), such as Einstein's relativity.

Moreover, feedback collected from the respondents resonated with other findings, such that an easy-to-use game board, as commonly mentioned by the respondents, signified engagement. A student-centered educational material that was found to be excellent and efficient may enhance engagement, foster cognitive abilities, and improve critical thinking (Izat et al., 2024; Permata et al., 2024; Lin & Cheng, 2022). In physics education, learners enjoy gamified strategies and learn well if the materials are easy to manipulate (Amado & Roleda, 2019). The significant improvement in understanding physics concepts after gamification (Da Silva & De Souza, 2024; Patar et al., 2024) enabled them to increase their participation in the learning process (Manihuruk & Sutabri, 2024).

Conclusion

This research endeavor, which sought to design, develop, and assess a game-based learning tool, generated positive and favorable results. Employing the PDCA framework to address the research problems, findings have determined that the "Special Relativity Game of Games (SRGoG)" attained a *very acceptable* and effective game-based learning tool for teaching and reviewing abstract concepts in Modern Physics. The board game's high ratings for content validity (M = 4.85, *SD* = 0.35) and for instructional and technical quality (M = 4.81, *SD* = 0.42) suggested its great potential to engage learning among students. Further validated by qualitative inputs, the SRGoG, as perceived by the participants, showed its student-centeredness approach, manifesting an informative and user-friendly design. Its simple and fun learning tasks enabled them to enjoy it. The strong endorsement by

students and teachers highlights the board game's utility in education and its promise as a novelty for engaging students in teaching and learning STR.

Recommendations

The researchers recommend incorporating the Special Relativity Game of Games in physics courses, teacher training programs, and workshops for science teachers. It is recommended that the feedback and proposed modifications of the participants be used for the improvement of the board game. Additionally, it is recommended to develop similar games on abstract subjects in physics, such as General Relativity, Quantum Mechanics, and Thermodynamics, to promote active learning and student-centered pedagogy. Finally, long-term studies are recommended to further investigate the influences of game-based learning on knowledge retention and motivation. These actions would supplement multimodal physics teaching with serious games, inquiry, digital tools, and real-world problem solving for a more profound conceptual understanding.

References

Adipat, S., Laksana, K., Busayanon, K., Asawasowan, A., & Adipat, B. (2021). Engaging students in the learning process with game-based learning: The fundamental concepts. *International Journal of Technology in Education, 4*(3), 542-552. https://doi.org/10.46328/ijte.169

Akimkhanova, Z., Turekhanova, K. M., & Karwasz, G. P. (2023). Interactive Games and Plays in Teaching Physics and Astronomy. *Education Sciences 13*(4), 393. https://doi.org/10.3390/educsci13040393

Alstein, P., Krijtenburg-Lewerissa, K., & Van Joolingen, W. R. (2021). Teaching and learning special relativity theory in secondary and lower undergraduate education: A literature review. *Physical Review Physics Education Research, 17(*2). https://doi.org/10.1103/physrevphyseducres.17.023101

Amado, C. M., & Roleda, L. S. (2019). Student Engagement in a Gamified Physics Course. *Proceeding of the International Conference on Future of Education*. 85-95. https://doi.org/10.17501/26307413.2019.2109

Assem, H. D., Nartey, L., Appiah, E. & Aidoo, J. K. (2023). A Review of Students' Academic Performance in Physics: Attitude, Instructional Methods, Misconceptions and Teachers' Qualification. *European Journal of Education and Pedagogy 4*(1), 84 – 92. DOI: 10.24018/ejedu.2023.4.1.551

Burmich, A., Mashkin, O., & Степанова, Н. Р. (2023). The Role of Game-Based Assessment for the Enhancement of Learning. *Springer International Publishing*. 356 – 369. https://doi.org/10.1007/978-3-031-48020-1_27

Byusa, E., Kampire E., & Mwesigye, A. R. (2022). Game-based learning approach on students' motivation and understanding of chemistry concepts: A systematic review of literature. *Helyon, 8*. https://doi.org/10.1016/j.heliyon.2022.e09541

Cortes, S. T., Lorca, A. S., Pineda, H. A., Tubog, R. & Vilbar, A. (2024). Strengthening science education in basic education through a professional development program on participatory action research for science teachers. *Social Sciences & Humanities Open*, *10*. https://doi.org/10.1016/j.ssaho.2024.101194.

D'Abramo, G. (2023). Troubles With Gravitational Frequency Shift Derived From Energy Conservation. https://doi.org/10.20944/preprints202308.0531.v2

Da Silva, S. L. R. & De Souza, L. H. M. (2024). Gamified Approaches for Teaching Physics: Didactic Sequence for the study of satellites and gps. *ARACÊ, 6*(3). 6799–6820. DOI: 10.56238/arev6n3-150.

Grande-de-Prado, M., Abella-García, V., Baelo-Álvarez, R., & García-Martín, S. (2025). Pre-service teachers' perceptions of educational escape rooms. *Journal of Technology and Science Education, 15*(2), 543-556. https://doi.org/10.3926/jotse.3020

Haleem, A., Javaid, M. Qadri, M. A. & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

Izat, M., Kyyakbayeva, U., Nurgaliyeva, S., Urinova, F., & Khallokova, M. (2024). The implications of educational games on the development of children's intellectual abilities. *International Journal of Innovative Research and Scientific Studies, 8*(1), 126–136. https://doi.org/10.53894/ijirss.v8i1.3578

Janiga, L., & Haverlíková, V. (2024). The Board Game Dixit as a Tool for The Development of Students' Physics Concepts. *International Journal of Innovation in Science and Mathematics Education, 32*(2). https://doi.org/10.30722/ijisme.32.02.006

Jeong, M. F. (2024*).* SMART Measuring Device: Utility Model for School Laboratories. *The Asian Conference on Education & International Development Conference Proceedings*. DOI: 10.22492/issn.2189-101X.2024.49.

Kacmaz, G. & Dubé, A. K. (2022). Examining pedagogical approaches and types of mathematics knowledge in educational games: A meta-analysis and critical review, *Educational Research Review, 35*. https://doi.org/10.1016/j.edurev.2021.100428.

Kamphorst, F., Vollebregt, M. J., Savelsbergh, E. R., & Van Joolingen, W. R. (2021). An Educational reconstruction of special relativity Theory for Secondary Education. *Science & Education, 32*(1), 57–100. https://doi.org/10.1007/s11191-021-00283-2

Kapanadze, M., Javakhishvili, N. & Dzagania, L. (2023). Investigating the relationship between students' interest in physics and environmental attitudes in Georgia. *EURASIA Journal of Mathematics, Science and Technology Education, 19*(8). https://doi.org/10.29333/ejmste/13429

Khuda, B., Muhammad, H., Shumaila, S., Bushra, N., & Muhammad, F. F. (2022). Effectiveness of digital game based learning strategy in higher educational perspectives. *Journal of Education and e-Learning Research, 9*(4), 258-268.10.20448/jeelr.v9i4.4247

Lasala, N. Jr. (2023). EDUTainment: Effectiveness of Game-based Activities in Teaching Ecosystem Topics. *Recoletos Multidisciplinary Research Journal, 11*(2), 69 – 83. https://doi.org/10.32871/rmrj2311.02.07

Leonardi, A. M., Mobilio, S., & Fazio, C. (2022). A teaching proposal for the didactics of Special Relativity: the spacetime globe. *Physics Education, 57*(4), 045002. https://doi.org/10.1088/1361-6552/ac5b82

Lin, Y. T., & Cheng, C.-T. (2022). Effects of Technology-Enhanced Board Game in Primary Mathematics Education on Students' Learning Performance. *Applied Sciences, 12*(22), 11356. https://doi.org/10.3390/app122211356

Machuqueiro, F., & Piedade, J. (2024). Modern board games and computational thinking: results of a systematic analysis process. *Educational Media International, 61*, 161–183. https://doi.org/10.1080/09523987.2024.2359762

Manihuruk, D. M., & Sutabri, T. (2024). Perancangan Bahan Ajar Berbasis Multimedia untuk Membangun

Pengalaman Belajar yang Menarik dan Interaktif. *Journal of Creative Student Research, 2*(6), 48–52. https://doi.org/10.55606/jcsr-politama.v2i6.4553

Mejeh, M., Hagenauer, G., & Gläser-Zikuda, M. (2023). Mixed Methods Research on Learning and Instruction—Meeting the challenges of multiple perspectives and levels within a complex field. FQS. https://doi.org/10.17169/fqs-24.1.3989

Mora, S., Di Loreto, I., & Divitini, M. (2021). The Interactive-Token Approach to Board Games. *Springer, Cham*. 138 – 154. https://doi.org/10.1007/978-3-319-26005-1_10

Muppalla SK, Vuppalapati S, Reddy Pulliahgaru A, & Sreenivasulu H. (2023). Effects of Excessive Screen Time on Child Development: An Updated Review and Strategies for Management. *Cureus, 15*(6). doi: 10.7759/cureus.40608.

Nguyen, V., Chau, C. K. B., & Tran, T. (2023). PDCA from Theory to Effective Applications: A Case Study of Design for Reducing Human Error in Assembly Process, *Advances in Operations Research*, 1-9. https://doi.org/10.1155/2023/8007474

OECD (2025), *Trends Shaping Education 2025*, OECD Publishing, Paris, https://doi.org/10.1787/ee6587fd-en.

Patar, M. N. A., Nazri, N. A. A., Razlan, R., Embong, Z., Ahmad, S., & Mahmud, J. (2024). Gamification and its Impact on Learning Fundamental Physics: A Meta-Analysis. *International Journal of Academic Research in Business & Social Sciences, 14*(9).

Paz-Garcia, J. M., Cerrillo-Gonzalez, M. del M., & Villen-Guzman, M. (2022). Boardgames as learning activities in stem degrees. *INTED Proceedings*. https://doi.org/10.21125/inted.2022.2146

Permata, N. A., Lubis, M., Perdana, I., Kurniawan, A., & Sembiring, A. (2024). Enhancing Educational Games: Addressing Design Challenges and Improving Effectiveness. *12th International Conference on Cyber and IT Service Management (CITSM),* 1–5. https://doi.org/10.1109/citsm64103.2024.10775684

Qi, J., Yan, Y. & Yin, H. Screen time among school-aged children of aged 6–14: A systematic review. *Global Health Research Policy, 8*(1). https://doi.org/10.1186/s41256-023-00297-z.

Rajkovic, A. I., Ruzic, M. S., & Ljujic, B. (2019). Board Games as Educational Media: Creating and Playing Board Games for Acquiring Knowledge of History. *International Association for Research on Textbooks and Educational Media, 11*(2). https://doi.org/10.21344/IARTEM.V11I2.582

Second Congressional Commission on Education. (2024). *(EdCOM 2) Miseducation: The failed system of Philippine education*. https://www.edcom2.gov.ph/#report

Tsarava, K., Moeller, K., Ninaus, M. (2019). Board Games for Training Computational Thinking. In: Gentile, M., Allegra, M., Söbke, H. (eds) Games and Learning Alliance. GALA 2018. Lecture Notes in Computer Science. *Springer, Cham*. *11385.* https://doi.org/10.1007/978-3-030-11548-7_9

Toscano de Brito Júnior, J. J., Rodrigues, R. L., & Amorim, A. N. (2023). An overview of Game-based learning studies and their relationship to student engagement. *Renote, 21*(1), 210–220. https://doi.org/10.22456/1679-1916.134348

Wan Ariffin, W. N. J., Chik, A., Rosli, R., & Nik Halman, N. N. A. (2024). Examining the Impact of Gamification Assessment on Motivation and Engagement in Learning Social Science Courses in Higher Education. *International Journal of Academic Research in Progressive Education and Development, 13*(3). https://doi.org/10.6007/ijarped/v13-i3/22332

Wenzel, A., Geiger, J.M., & Liening, A. (2025). Beyond the screen: Investigating the added value of realism

enabled by the metaverse in digital game-based entrepreneurial learning. *Computers in Human Behavior Reports, 19*. https://doi.org/10.1016/j.chbr.2025.100738

Zheng, Y., Zhang, J., Li, Y., Wu, X., Ding, R., Luo, X., Liu, P. & Huang, J. (2024). Effects of digital game-based learning on students' digital etiquette literacy, learning motivations, and engagement, *Heliyon, 10*(1), https://doi.org/10.1016/j.heliyon.2023.e23490.

Author Information

John Rey Busime
https://orcid.org/0009-0007-3257-4681
Carlos Hilado Memorial State University
Talisay City, Negros Occidental
Philippines

Vincent Algarme
https://orcid.org/0009-0000-7388-2890
Carlos Hilado Memorial State University
Talisay City, Negros Occidental
Philippines

Joeylene Bene
https://orcid.org/0009-0004-9899-0395
Carlos Hilado Memorial State University
Talisay City, Negros Occidental
Philippines

John Lester Polines
https://orcid.org/0009-0004-4063-8049
Carlos Hilado Memorial State University
Talisay City, Negros Occidental
Philippines

Faith Celeste Ole
https://orcid.org/0000-0001-6248-4168
Carlos Hilado Memorial State University
Talisay City, Negros Occidental
Philippines
Contact e-mail: *faith.celeste.ole@chmsu.edu.ph*