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GAMIFIED MOBILE APPS' IMPACT ON ACADEMIC PERFORMANCE OF GRADE 8 IN A MAINSTREAM PHYSICS CLASS

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ABSTRACT

Aim/Purpose	This research project aims to create a gamified instructional material tailored for Grade 8 students that includes a partially deaf student attending mainstream Science classes. The developed gamified mobile application underwent expert review and was used as an intervention tool to enhance academic performance in Physics among these students.
Background	In the Philippines, there is a lack of accessible Science Instructional Materials for students with special educational needs, making inclusive education challenging. To address this, teachers need to enhance resources for inclusivity without compromising learning enjoyment. Gamification, a technique that increases student engagement, is critical. However, only some resources combine gamification and inclusion, highlighting the need for Science teachers to develop such materials.
Methodology	Using a quantitative descriptive approach, the researchers assessed students' competencies in Physics 8, identifying strengths and weaknesses. This data guided the creation of targeted interventions. A systematic literature search helped identify game design components from prior research, aiding the development of the Science-Inclusive Gamified Mobile Application (SIGMA). This application integrated various features, leading to a significant improvement in

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	students' academic performance. Pre-test and post-test analyses showed substantial progress.
Contribution	The gamified mobile application positively affected eighth-grade students, including one with hearing impairment, enhancing their educational experience and interest in challenging topics. The research underscores the importance of teachers adopting gamified technologies to foster proactive knowledge acquisition.
Findings	The Grade 8 pupils, with one partially deaf student, responded positively to the gamified mobile application, which made the educational experience more enjoyable and increased students' interest in topics that are often least comprehended. Design elements like leaderboards and feedback were integrated into the Science Gamified Mobile App (SIGMA). Usage resulted in significant academic improvement, supported by pre-test/post-test scores (pre: mean 10.15, post: mean 26.73). The study highlights gamification's impact on performance with substantial empirical evidence.
Recommendations for Practitioners	Teachers in various disciplines should keep adopting and utilizing gamified technologies that encourage and aid their students' imaginative and proactive knowledge acquisition.
Recommendations for Researchers	These research results provide important insight into the impact of gamification on students' academic performance. However, substantial challenges must be addressed to analyze and interpret these results. Integrating gamification in settings with more participants and longitudinal studies that examine the influence over time would be intriguing because it would allow for an in-depth investigation into the results acquired.
Impact on Society	The investigation results suggest that the mobile application with gamification elements had an essential effect on the academic achievement of eighth-grade students, including a student with a partial hearing impairment. The results of the present investigation may contribute significantly to the field of education by offering guidance to teachers who aim to integrate gamification into their Science course material within a classroom environment that promotes inclusivity. The research has identified crucial design elements for developing a practical gamified mobile application.
Future Research	It would be intriguing to duplicate the kind of intervention carried out in this study in longitudinal research since it would allow us to know the impacts of gamification over a prolonged time. It is also vital to understand, through studies that are either more experimental or quasi-experimental, the effects of gamified mobile applications on students with various hearing impairments. It is also recommended to conduct a subsequent research phase utilizing the gamified mobile application with participants from other demographic groups.

Keywords: academic performance, gamification, inclusivity, mobile application development, physics

INTRODUCTION

The global education landscape has recently witnessed a heightened focus on pursuing inclusive and equitable education. This emphasis reflects the understanding that diverse student populations require tailored instructional approaches to ensure equal learning and academic success opportunities. Among these diverse groups, partially deaf students stand out, facing unique challenges within tradi-

tional educational settings. This research addresses the critical and pressing need for developing specialized instructional materials designed to support partially deaf students in Europe, Western countries, and developing nations where inclusive education is a foundational principle.

The World Health Organization (WHO) has recently estimated that there are over 466 million people worldwide with disabling hearing loss, which is expected to increase significantly in the coming decades (WHO, 2021). Partial hearing loss can profoundly impact a student's ability to access and engage with educational content in mainstream classrooms. Despite legislative and policy frameworks in Europe and Western countries promoting inclusive education, a conspicuous gap persists in providing instructional materials that account for the unique needs of partially deaf students (European Agency for Special Needs and Inclusive Education, 2020).

Partially deaf students grapple with an array of challenges when navigating mainstream educational settings. These challenges encompass difficulties following verbal instructions, participating in class discussions, and accessing audio content, which can severely hinder their learning progress (Sharma et al., 2017). While assistive technologies such as hearing aids and cochlear implants provide some support, they do not comprehensively address the distinctive instructional requirements of this student population (Yoshinaga-Itano et al., 2018).

Despite the evident and pressing need for instructional materials tailored to the needs of partially deaf students, a noticeable gap exists in research and development in this domain across Europe, Western countries, and developing nations like the Philippines. The recently released findings from the Programme for International Student Assessment (PISA) 2018 underscore a concerning reality: Filipino students exhibit lower proficiency levels in Science than their global peers. This revelation serves as a clarion call, urging educators to embark on a transformative journey within the country's educational landscape.

The significance of scientific literacy among students cannot be overstated, particularly given their role in the knowledge-driven economy of the 21st century. Science has emerged as a fundamental driver of progress in contemporary society, offering vast opportunities for innovation, societal transformation, and the resolution of critical global challenges. The PISA results expose a glaring disparity that threatens to impede the Philippines' ability to harness scientific advancements and secure a prosperous future for the next generations.

The complexity of this challenge is magnified when we consider the inclusion of partially deaf students in regular classroom settings. One contributing factor to the low science proficiency is the necessity to provide equal opportunities for students with special educational needs. Society's aim should not merely be equality and equity in education; it should strive for equal opportunity and social justice. Within the educational system, true social justice means eliminating obstacles that hinder all learners from receiving a high-quality education, particularly during times of crisis, such as the COVID-19 pandemic.

According to the United Nations Human Rights Commission (2020), the COVID-19 outbreak impacted all sectors of society, with individuals with disabilities bearing a disproportionate burden of psychological, economic, and institutional challenges stemming from the pandemic response. While everyone is susceptible to the strains of a global crisis, individuals with disabilities are often the most marginalized and disadvantaged. UNESCO (2017) explicitly underscores that the 2030 Agenda for Sustainable Development offers a unique opportunity to build a more equitable and inclusive society. UNESCO defines inclusive education as a strategy aimed at reshaping educational structures and learning environments to meet the needs of diverse learners. Although many nations have embraced this concept, implementing full inclusion for students with disabilities in typical classrooms remains a formidable challenge. Despite decades since the Salamanca Statement, the Philippines continues grappling with inclusive education. Discrimination, marginalization, and exclusion persist within the Philippine educational system (Del Corro-Tiangco & Bustos, 2014). The COVID-19 pandemic exacerbated these difficulties due to a shortage of essential services from Special Education instructors

and the unavailability of assistive technology, such as books with audio for visually impaired individuals, Braille print materials, and audio services or graphics customized for Persons with Disabilities (PWDs) (Dianito et al., 2021).

Notably, the complexity of this challenge increases when we consider including partially deaf students in regular classroom settings. In the Philippines, there is a scarcity of accessible Science Instructional Materials designed for children with special educational needs. Data from the World Federation of the Deaf (WFD), indicates that approximately 66 percent of deaf people are concentrated in developing countries (Venerable & Tatlonghari, 2015). A 2009 study highlighted a high incidence of deafness in the Philippines, with two to three deaf individuals for every 1,000 Filipinos. However, this statistic is over a decade old. A 2021 report from the World Health Organization (WHO) estimated that around 360 million people worldwide suffer from debilitating hearing loss, yet a relatively small number of researchers have delved into the unique educational needs of this substantial population.

Implementing Inclusive Education (IE) presents a formidable challenge as instructional materials must be adapted to meet the requirements of all students. It is recommended that instructional designers focus on enhancing teaching resources to create an inclusive environment without compromising students' enjoyment of learning in inclusive classrooms. In fostering an enjoyable learning environment, gamification is key to increasing student engagement in the Science Classroom. However, educational resources effectively combining Gamification with Inclusion are scarce. Saman et al. (2019), compiled a list of valuable gamification techniques for inclusive classrooms, emphasizing the importance of rewarding and challenging game mechanisms such as stages, leaderboards, and achievements to promote player engagement and enhance educational outcomes. Economou et al. (2020) research on the effects of gamification on students with disabilities underscored the value of customized feedback and flexible game design to meet the needs of learners of all abilities. Another approach to creating inclusive gamified learning environments for children with special needs was proposed by Bidarra et al. (2015).

Studies consistently demonstrate that gamification in an inclusive science classroom can significantly improve student academic achievement. Therefore, there is an imperative to engage Science teachers in the development of Science Instructional materials that are inclusive and gamified, with the goal of elevating academic performance within inclusive Science Classrooms. This study's primary objective is to explore the potential benefits of developing a gamified mobile application that could be an inclusive instructional tool to enhance the science proficiency of Grade 8 students with one partially deaf student enrolled in mainstream classes. The application aims to bolster science learning by integrating customized content, interactive features, and visual cues to surmount communication barriers and stimulate engagement.

Furthermore, this study centers on designing and developing a mobile application that incorporates gamification elements closely aligned with the science curriculum. These elements include captioning support and visual representations of scientific concepts. The research aims to investigate the impact of this instructional material on the knowledge acquisition of Grade 8 students with one partially deaf student enrolled in mainstream classes. The outcomes of this research promise to provide invaluable insights into the field, with the ultimate goal of enhancing the educational experience of partially deaf Filipino students within mainstream classrooms. Achieving this goal necessitates the creation of inclusive, accessible, and engaging learning opportunities in the realm of science education.

Specifically, the study focuses on the following research questions:

1. What learning competencies in Physics do Grade 8 students with one partially deaf student enrolled in mainstream class need to improve?
2. What are the design elements that will serve as a guide in the development of the SIGMA to improve the academic performance of Grade 8 students with one partially deaf student enrolled in a mainstream Physics class?

3. Is there a significant difference between the pre-test and post-test scores of the Grade 8 students with one partially deaf student enrolled in mainstream Physics class?

Hypothesis:

H_A: There is a significant difference in students' academic performance before and after using the SIGMA.

H_O: There is no significant difference in students' academic performance before and after using the SIGMA.

SCOPE AND LIMITATION OF THE STUDY

This study was conducted in one of the public schools in Mandaluyong, Philippines with enrolled Students with Educational need, specifically, with at least one mute or partially deaf student during the first quarter of the Academic 2022-2023. The topics included in the Science-Inclusive Gamified Mobile Application (SIGMA) were based on the least mastered competencies in Science 8 of the students after the Pretest, and these are all under the topic of Electricity. Science-Inclusive Gamified Mobile Application incorporated leaderboards, point systems, timers, competition, advancement, and storytelling as the game design or elements. The developed Science-Inclusive Gamified Mobile Application was utilized only in one regular Grade 8 Science heterogeneous class with at least partially deaf student who can only utilize assistive technologies like hearing aid. The utilization of SIGMA in a regular Grade 8 Science Class does not cater to those students who need to utilize complicated assistive technologies like students with Autism, Brain-Injury, Intellectual Disabilities, blind students, and other special educational needs who will also be attending the same Grade 8 Science heterogeneous class with either partially deaf students. The Science-Inclusive Gamified Mobile Application is only designed for students who are partially deaf student. Furthermore, the study focuses only on the effect of the Science-Inclusive Gamified Mobile Application on the academic performance and excludes the correlation of Science-Inclusive Gamified Mobile Application in the socio-economic status, gender, resources, short internet band, the brand of mobile devices and ethnicity.

LITERATURE REVIEW

GAMIFICATION FOR INCLUSIVE EDUCATION

Gamification, integrating game elements into non-game contexts, has emerged as a promising approach to enhance student engagement and interactive learning experiences in educational settings (Yusof et al., 2021). With the rapid expansion of e-learning platforms, the incorporation of gamification principles into education has gained increasing attention (Bennani et al., 2022). Moreover, accessibility in education has become a central concern, with the assertion that all instructional materials should be inclusive and cater to individuals with disabilities (Rice & Ortiz, 2020).

While gamification offers a potential solution to engage students and motivate them to achieve learning objectives (Landers et al., 2017), there remains a gap in the literature concerning the intersection of gamification and inclusion (Bleumers et al., 2012). Recent research has indicated that students' familiarity with digital games and their interest in technology can be harnessed to enhance learning outcomes (Landers et al., 2017).

This research builds upon the foundation laid by previous studies. It investigates the impact of gamification on the accessibility and inclusivity of educational materials, particularly for individuals with partially deaf disabilities. In a pilot study involving a diverse group of participants, including individuals with disabilities and professionals in technological design, the use of gamification components within an eVideo program was examined (Umar, 2021). The findings revealed a generally positive reception of gamification elements, although some participants expressed preferences for non-competitive learning approaches.

Furthermore, recent studies have highlighted the potential of gamification in supporting specific learning needs, such as assisting blind students in acquiring essential skills (Chang et al., 2022) and facilitating the learning of scientific vocabulary for individuals with intellectual and developmental disabilities (Kim et al., 2021). Additionally, the development of accessible interactive instructional software and tools has expanded opportunities for inclusive education (Araujo et al., 2017; Nguyen et al., 2018).

As the educational landscape evolves, it is imperative to assess the adoption and effectiveness of gamification in various instructional settings (Krath et al., 2021). Understanding educators' perspectives, mastery of gamification techniques, and the overall usability of gamified educational tools is critical to successfully integrating into diverse learning environments (Alzahrani & Alhalafawy, 2023).

This research aims to contribute to the ongoing discourse on gamification in education, shedding light on its potential to enhance inclusivity, accessibility, and learning outcomes. By exploring the experiences and preferences of diverse learners, including those with partially deaf disabilities, it seeks to provide valuable insights into the design and implementation of gamified educational materials that cater to the needs of all students.

Effect of Gamification in Academic Performance

In pursuing enhancing the educational experiences and outcomes of partially deaf students, a growing body of research has illuminated the potential of gamification as a powerful tool. In a study conducted in Western countries in 2023, laid the foundation for understanding gamification's role in deaf education (Irwanto et al., 2023). This research showcased significant improvements in academic performance when gamification elements were integrated into the curriculum. Notably, gamification boosted student engagement, motivation, and knowledge retention, underscoring its potential to bridge the educational gap for partially deaf learners.

Expanding the horizon to European countries, Müller and Schmidt's 2020 study provided a comprehensive European perspective on gamification in deaf education (Müller & Schmidt, 2020). Their research uncovered a positive correlation between gamification and improved academic outcomes among partially deaf European students. Additionally, the study highlighted how gamified activities fostered improved communication and teamwork skills among students, emphasizing the holistic benefits of gamification beyond academic performance. Garcia and Anderson's 2017 literature review encompassed both Western and European contexts, revealing the cognitive advantages of gamification in education for partially deaf students (Garcia & Anderson, 2017). By enhancing cognitive skills, language development, and problem-solving abilities, gamification emerged as a potent tool for promoting academic success and skill development within this demographic.

Turner and Clark's 2019 study focused on the impact of gamified mathematics lessons on partially deaf students (Turner & Clark, 2019). Their research found that gamification contributed to higher math scores and kindled a heightened interest in the subject among deaf students. This study underscored the adaptability of gamification in tailoring educational approaches to specific subjects and regions. Inclusive education took a significant stride forward with Van der Linden and De Jong's 2021 case study conducted in the Netherlands (Van der Linden & De Jong, 2021). This study emphasized the effectiveness of inclusive gamification techniques by incorporating accessibility features into gamified learning platforms. The research demonstrated improvements in academic performance and promoted inclusivity in education, ensuring that all students, regardless of their hearing abilities, can access quality education.

In summary, the amalgamation of these studies from Western and European countries underscores the transformative impact of gamification on academic performance among partially deaf students. Gamification enhances engagement and motivation and fosters cognitive development, teamwork, and inclusivity. (Garcia & Anderson, 2017; Irwanto et al., 2023; Müller & Schmidt, 2020; Turner & Clark, 2019; Van der Linden & De Jong, 2021).

Gamification has emerged as a promising educational strategy to enhance learning outcomes among deaf and hard-of-hearing students in developing countries. The study conducted by Sanchez et al. (2020) investigates the effectiveness of gamification in this context and finds that educational games and interactive quizzes significantly boost engagement and motivation, ultimately leading to improved academic performance (Sanchez et al., 2020). This underscores the potential of gamification as a powerful tool for enhancing the educational experience of students with hearing impairments.

Gupta and Goyal (2022) conducted a case study in India, focusing on the impact of gamified learning in inclusive education for deaf students. Their research reveals that integrating gamified elements into the curriculum increases participation and enhances comprehension and retention of educational content. This study highlights the adaptability of gamification in diverse educational settings, including those in developing countries.

In South Africa, Van der Merwe (2019) explored the application of gamification in mathematics education for deaf students. Their findings demonstrate that gamification strategies, such as math-focused apps and interactive exercises, significantly improve math proficiency and overall academic performance (Van der Merwe, 2019). This underscores the potential of gamification to address specific subject-related challenges faced by deaf students in developing countries.

India et al. (2021) conducted research in low-resource settings, emphasizing the potential of digital games in promoting inclusive education for deaf learners. Their study highlights gamification's cost-effectiveness and engagement potential, making it a desirable option for resource-constrained environments in developing countries (India et al., 2021). This suggests that gamification can bridge educational gaps by providing accessible and effective learning tools.

Ndegwa et al. (2023) focused on literacy skills enhancement among deaf children in Kenya using gamified reading apps. Their results indicate that gamification enhances reading proficiency and instills a passion for reading in deaf students, thereby positively impacting their overall academic performance (Ndegwa et al., 2023). This study showcases the broad applicability of gamification in addressing literacy challenges among deaf students in developing nations.

Finally, Baars et al. (2022) explored the use of gamified learning environments to motivate and improve the academic performance of deaf students in science education in Pakistan. Their research findings indicate that gamification increases motivation and enhances comprehension and retention of scientific concepts. This study emphasizes the potential of gamification to make STEM education more accessible and engaging for deaf students in developing countries.

In summary, the reviewed literature highlights the transformative potential of gamification in improving the academic performance of partially deaf students in developing countries like the Philippines. These studies demonstrate that gamification strategies offer innovative and inclusive approaches to enhance engagement, motivation, and learning outcomes among this student population.

MATERIALS AND METHODS

The utilization of the descriptive research design enabled the researcher to furnish thorough background information on the current learning competencies exhibited by the students enrolled in Physics 8. The modified pre-assessment from San Luis et al., 2019 was administered once the researcher received the letter of approval to conduct the study. The pre-assessment results were the basis of the lessons to be included in the Science-Inclusive Gamified Mobile Application. This method facilitated identifying both proficient and deficient areas to be improved. The data obtained from the study provides significant insights that can assist researchers in designing specific interventions and approaches aimed at improving the educational experience and achievements in Physics 8. The utilization of the descriptive research design enabled the researchers to furnish thorough background information on the current learning competencies exhibited by the students enrolled in Physics 8. This method facilitated the identification of students' least mastered learning competencies that need improvement.

The data obtained from the study provides significant insights that can assist the researcher in designing specific interventions and approaches to improve the educational experience and achievements in Physics 8. Implementing a systematic literature search approach facilitates identifying and analyzing various game design elements that have been employed in previous research studies. It allows the researcher to investigate various game design elements incorporated in the design and development of educational tools, such as the Science-Inclusive Gamified Mobile Application (SIGMA). A systematic literature search was conducted across all three databases, Google Scholar, Web of Science, and CrossRef, to draw a wide net for papers that may be included in the study. This method was essential given that gamification has been utilized in various contexts on various aspects of education. Boolean search strings that include the words "gamification," "gamify," "gamified," and "gamifying," as well as "inclusive education," "learner," "user," and "participant," and "effect," "motivation," "achievement," "performance," and "effect," metacognition, engagement). It was decided not to utilize the wildcard character "*" in the search keywords because some databases do not permit it.

Inclusion and Exclusion Criteria

In order for studies to be considered for inclusion in this meta-analysis, they needed to meet the following criteria: (1) needed to have been published between January 1, 2016, and December 31, 2021 (studies that were still in the press were considered), (2) needed to explicitly state learners as the target group at any level of education in a conventional classroom setting, (3) needed to adopt a quasi-experimental design that compared a gamification intervention to one without gamification as a between-subject condition, and (4) needed to involve a significant amount of time and effort. Utilizing these criteria for inclusion and exclusion, the researcher screened the articles using the systematic techniques provided in the next section (Moher et al., 2009). Presented in Figure 1 is the PRISMA diagram for the search, identification, screening, coding, and extraction processes.

Additionally, the publications had to indicate that the researchers used experimental or quasi-experimental approaches. Because solely qualitative approaches are unsuitable for meta-analysis, the researcher intentionally chose to eliminate such papers from consideration. As a result of this phase, 143 manuscripts were considered in the subsequent stage. The subsequent phase of the process involved the researcher carefully reading the full-text papers in the dataset and then systematically coding and extracting information from those publications. This research was used to inform the development of the guide. The following information was gleaned from each document and included in the codebook:

- Name of the Authors
- Title of the Manuscript
- Year of publication
- Source
- Publisher
- Subject Matter
- Research Design (one (1) for experimental, two (2) for quasi-experimental)
- Dependent measurement domain (1-cognitive, 2-emotional, 3-behavioral)
- Environment for instruction (where one is digital, two is physical, and three is blended)
- Gamification elements (1. Leaderboards, 2. Badges, 3. Points, 4. Advancement, 5. Responsive Feedback, 6. Storytelling, 7. Avatars, 8. Timed Activity, 9. Collaboration, 10. Competition, 11. Mission)
- Population
- The data necessary for conducting statistical analyses and determining effect sizes

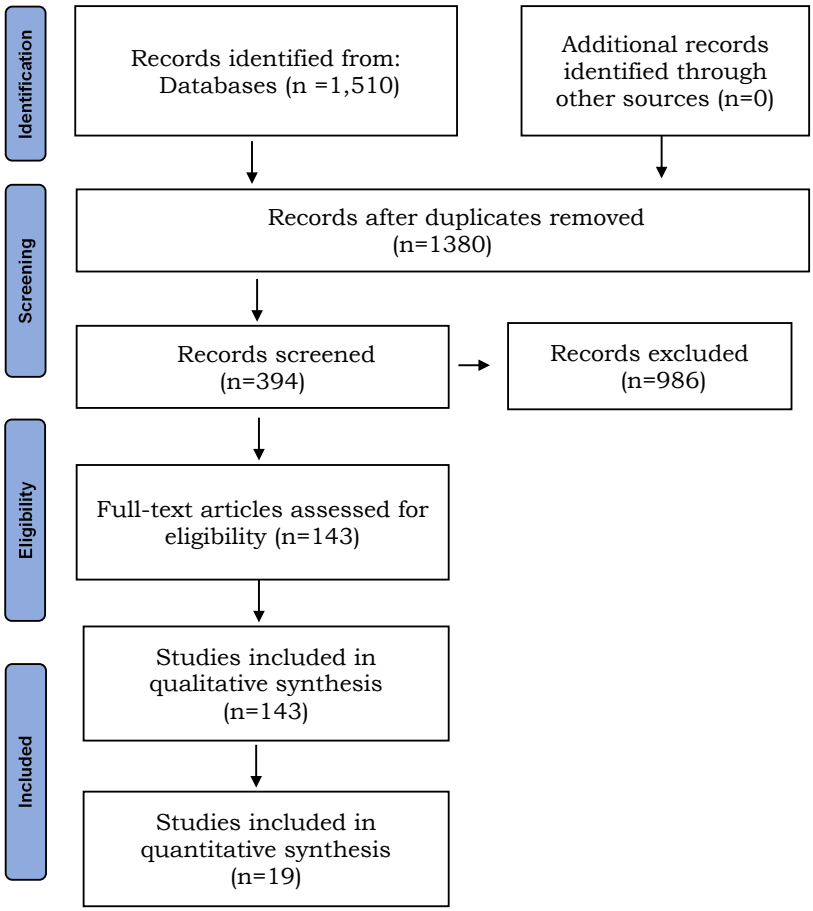

Figure. 1 The current study's PRISMA flowchart

The researcher extracted publishing details, gamification moderators, and contextual moderators from the codebook. The researcher created a table documenting the study publication, moderators, and effect size details (n, M, and SD).

The study was conducted in one of the public secondary schools in Mandaluyong City, Philippines, that caters to students with special educational needs, specifically partially deaf students attending the mainstream classroom. A Grade 8 heterogeneous mainstream class with 41 students taking up Science 8 for School Year 2021-2022 was the study's participant. The Science 8 mainstream class was chosen since the objective of this study is to develop a science-inclusive gamified mobile application that helps teachers accommodate students with special educational needs, specifically a partially deaf student, and give all the students an equal opportunity to learn science concepts.

The tabulated data were used to present the study's findings. Statistical software such as the Statistical Package for Social Science (SPSS) was used to process the data. The collected data was analyzed using relevant statistical techniques. This study used descriptive statistics such as means and standard deviation. Based on pre- and post-assessment, the data were examined to determine the acceptability and inclusivity of the Science-Inclusive Gamified Mobile Application. Additionally, the t-test for correlated means (paired samples) was utilized as a statistical tool, as one of the study's objectives was to determine whether or not the computed difference between the pre-assessment and post-assessment is statistically significant. Statistical analysis was used using the Comprehensive Meta-Analysis (CMA) Version 3 developed by Biostat, Inc. to analyze different studies for the meta-analysis part.

RESULTS AND DISCUSSIONS

LEAST MASTERED COMPETENCIES TO BE INCLUDED IN SIGMA

The developed and validated Pre-Assessment was used to identify the students' least mastered competencies in Physics 8. The assessment consisted of thirty (30) items that determined the least mastered competencies that needed to be improved using the SIGMA as intervention material in Physics 8. The following Most Essential Learning Competencies (MELCS) were included in the assessment, namely: Newton's Three Laws of Motion (MELC 1), Work using constant force (MELC 2), potential and kinetic energy (MELC 3), propagation of sound (MELC 4), properties and characteristics of visible light(MELC 5), effects of heat and temperature (MELC 6), the relationship of voltage, and resistance current (MELC 7), electric power (MELC 8), and electric energy at home and home circuitry (MELC9).

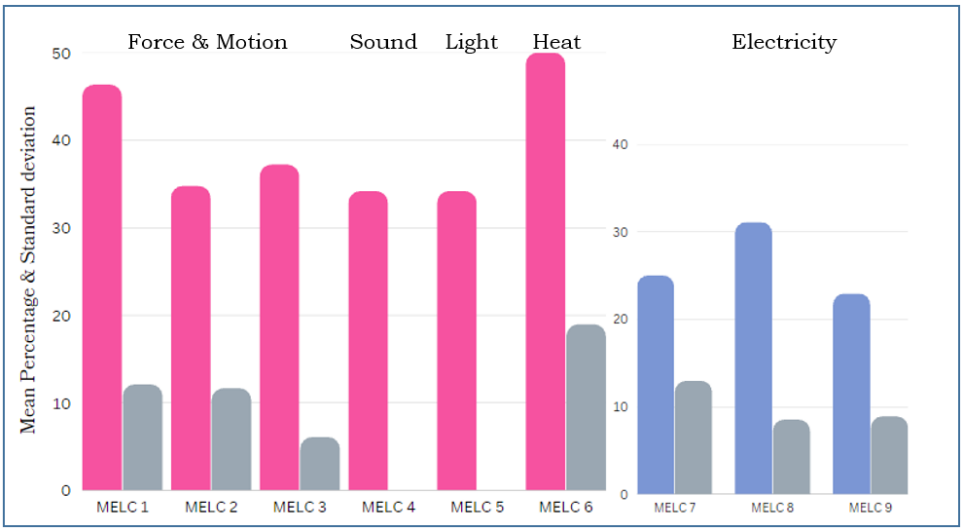

Figure 2. Competency proficiency rate in Physics 8

Figure 2 visually illustrates the percentage of students who answered correctly for each competency. The pink and violet bar represents the Mean Percentage while the gray bar represents the Standard Deviation. Notably, Most Essential Learning Competency (MELC) 9 had the lowest mean percentage, at 22.93 % out of 100%. This suggests that this competency was the least mastered despite covering multiple items. Most Essential Learning Competency (MELC) 7 has an average percentage of 25%, and Competency 8 has an average percentage of 31.10%. Therefore, it can be found that Grade 8 struggled the most with electricity-related topics.

In addition, Most Essential Learning Competency (MELC) 6 had the highest proportion of correct responses at 50%. However, its standard deviation was comparatively high at 18.971%, indicating a wide range of responses around the mean percentage. Most Essential Learning Competency (MELC) 9 had the lowest mean percentage, with a value of 22.93% and a standard deviation of 8.895%. Compared to Most Essential Learning Competency (MELC) 6, the responses for Most Essential Learning Competency (MELC) 9 were more concentrated around the mean. The percentage of students who answered all competencies correctly was 33.82%, with a standard deviation of 12.449, indicating a significantly low level of mastery of the given competencies.

The data herein presented can be connected to the Programme for International Student Assessment (PISA) 2018 results. In which students acquired low proficiency in Science even after attending the traditional approach to teaching Physics 8. Macaya (2020) looked at how hard it is to understand electrical circuits, which turned out to be one of the most widely named least-mastered skills in physics

education. Through a review of real-world studies, the writers found that persistent misconceptions and difficulty understanding abstract ideas are the main things that keep students from learning. They suggested that students learn more about electrical circuits by doing hands-on tasks, using visualization tools, and using them in real life.

In addition, R. T. Santos and Cruz (2019) conducted research to investigate the factors that contribute to the poor academic performance of Filipino students in the subject of Physics. They identified several vital variables, such as insufficient training for teachers, a scarcity of resources and laboratory equipment, and an absence of an emphasis on learning strategies based on inquiry. Because of the combined effects of these characteristics, the students have a restricted comprehension of the material, and their level of engagement with it is low; as a result, they cannot obtain improved performance outcomes.

The study by Mbonyiryivuze et al. (2019) focused on investigating the difficulties encountered in comprehending electric circuits, which have been identified as a significant weakness in electricity education. The study's findings indicate that students encountered challenges in understanding circuit diagrams, recognizing components, and analyzing series and parallel circuits. Finding the least-mastered competencies can boost student learning. Educators can help students develop in their weakest areas by targeting education and support. Targeted education can boost student achievement, research shows. For example, instructors might provide additional reading instruction and practice activities to improve reading comprehension. Educators can assist students to improve by concentrating on their weakest skills. Once educators have identified the areas in which students are suffering, they can decide what instructional strategies and resources to assist students' progress. The research conducted by L. M. Santos and Hernandez (2019) indicates that there is increasing concern regarding the performance of Filipino students in the field of Physics. The researchers observed that many students in the Philippines encounter difficulties in understanding basic principles and applying them to tackle Physics-related problem-solving exercises. The observed low levels of performance in Physics can be attributed to several factors, such as insufficient instructional resources, restricted availability of high-quality laboratory facilities, and an insufficiency of competent Physics educators.

Reyes et al. (2020) conducted a study to investigate the factors contributing to the sustained underperformance of Filipino students in the subject of Physics. The researchers emphasized the influence of socio-cultural factors on students' motivation and self-efficacy in learning Physics. Specifically, the prevalence of a "science is difficult" mindset among students and parents was identified as a hindrance to their learning. The study has identified language barriers as a notable obstacle in the field of Physics education. It has been observed that a considerable number of Physics textbooks and instructional materials are predominantly available in English, which can be problematic for students who have a higher proficiency in Filipino.

The Department of Education in the Philippines has highlighted the necessity of implementing specific interventions to tackle the issue of poor academic performance among Filipino students in the field of Physics. The report recommends the adoption of improved teacher training programs, curriculum modifications to conform with international benchmarks and greater allocation of resources towards science facilities and materials. In summary, the existing research highlights the enduringly inadequate academic achievement of Filipino students in Physics. The primary research objective of this study is to investigate the imperative need for the development of gamified instructional materials tailored specifically for Grade 8 students with one partially deaf student attending the mainstream Physics class. This research endeavors to comprehensively assess the educational needs of this specific student demographic, seeking to identify the barriers they encounter in conventional learning environments and determine how gamified instructional materials can effectively address these challenges. The study will involve the meticulous design and creation of gamified learning resources aligned with the Science 8 curriculum, integrating key game design elements.

Design Features of Science-Inclusive Gamified Mobile Application

Table 1 provides the effect sizes broken down by the various gamification design elements to be incorporated in the development and design phase of the Science-Inclusive Gamified Mobile Application. Most studies used leaderboards, badges, points, advancements, responsive feedback, storytelling, timed activity, and competition. Therefore, these game design elements were the design features incorporated in the development of the Science-Inclusive Gamified Mobile Application to improve academic performance in Physics 8. Game elements influence changes in attitudes and behaviors. This argument provides justification for the use of gamification-like game elements to affect relevant student outcomes (such as motivation) that moderate student learning outcomes.

Table 1. Gamification design elements' effect size data

Gamification Element	Effect Size and 95% Confidence Interval							
	N	k	G	SE	Lower	Upper	Z	p
Leaderboard	729	17	1.142	0.273	0.606	1.678	4.178	< .001
No Leaderboard	35	1	0.000	0.239	-0.469	0.469	0.000	1.000
Badges	532	13	1.333	0.357	0.633	2.032	3.736	< .001
No Badges	232	5	0.460	0.262	-0.053	0.974	1.758	0.079
Points	733	17	1.085	0.274	0.548	1.621	3.964	< .001
No Points	31	1	0.962	0.262	0.448	1.476	3.667	< .001
Advancements	628	15	1.180	0.308	0.576	1.783	3.832	< .001
No Advancements	136	3	0.622	0.531	-0.419	1.662	1.171	0.242
Responsive Feedback	531	10	1.463	0.420	0.640	2.287	3.482	< .001
No Responsive Feedback	233	8	0.638	0.222	0.202	1.073	2.870	0.004
Storytelling	291	6	2.121	0.801	0.551	3.690	2.649	< .001
No Storytelling	473	12	0.626	0.179	0.274	0.977	3.491	< .001
Avatars	221	4	0.750	0.342	0.080	1.421	2.195	0.028
No Avatars	543	14	1.192	0.345	0.515	1.869	3.452	0.001
Timed Activity	352	11	1.422	0.442	0.555	2.289	3.214	0.001
No Timed Activity	412	7	0.600	0.220	0.168	1.033	2.724	0.006
Collaboration	637	16	1.081	0.295	0.503	1.658	3.667	< .001
No Collaboration	127	2	1.105	0.731	-0.327	2.537	1.513	0.130
Competition	600	14	1.210	0.323	0.576	1.844	3.742	< .001
No Competition	164	4	0.659	0.420	-0.165	1.483	1.568	0.117
Mission	0	0	***	***	***	***	***	***
No Mission	764	18	1.074	0.260	0.565	1.583	4.134	< .001

* N=sample size *k=No. of Literatures *G=Effect size *SE=Standard Error *Z= Z-score *p= p-value

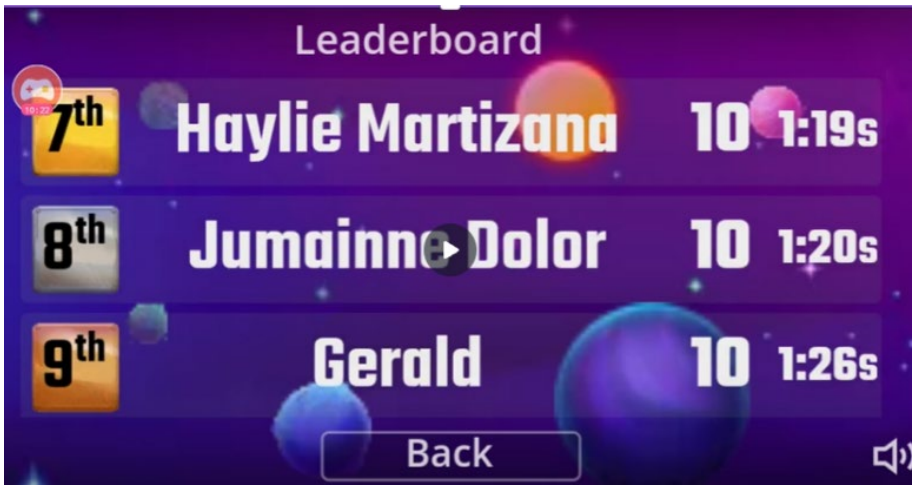

Figure 3. SIGMA Leaderboard

According to the data, the effect size of research that employed leaderboards was larger (g=1.142) than that of those that did not (g=0.000), suggesting that leaderboards did have a statistically significant impact. A scoreboard was included in SIGMA, a mobile app that gamified Science for everyone. The leaderboard displays users' accomplishments by projecting their scores after they have completed a specific assignment. Although the function is not intended for competition, it may increase interest among players aiming for a high score. More and more mobile games are including leaderboards in their gameplay. Competition amongst users is one strategy that might be utilized to boost engagement and retention in mobile apps.

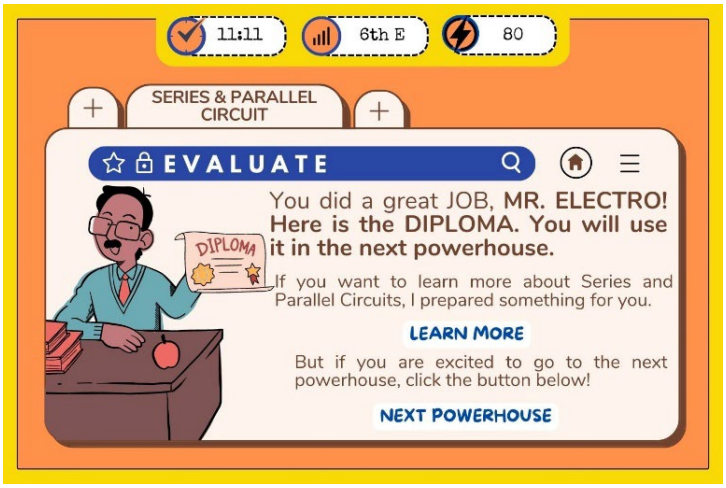

Figure 4. SIGMA Badges

The results of the systematic literature search suggest that the incorporation of badges in research studies yielded a significantly greater effect size (g=1.333) in comparison to studies that did not utilize badges (g=0.460). As shown in Figure 4, the Science Inclusive Gamified Mobile Application has incorporated badges as its second feature. In the interface of the mobile application, these badges appear whenever there is an interval between tasks. This category encompasses various forms of communication, such as greetings, cautions, directives, and similar types of messages.

Figure 5. SIGMA Point System

The presence of a point system has a slightly higher effect on the outcome variable than the absence of a point system. This is in comparison to the fact that the point system was not present. In general, an impact size of 1.085 (with a point system) is thought to represent a moderate to significant effect. In contrast, an effect size of 0.962 (without a point system) is thought to reflect a small to moderate influence. In addition to its other capabilities, the mobile app incorporated a point system, as shown in Figure 5. These are the exact metrics that show how well students performed after they had completed each level.

Figure 6. SIGMA Advancements

The effect sizes in the systematic literature search suggest that the inclusion of game advancement in gamification yields a more significant impact compared to studies that do not incorporate game advancement. The results suggest that game advancement has a relatively strong relationship with the measured outcome, as indicated by the effect size of 1.180. In contrast, studies that did not incorporate game advancement in gamification showed a moderate relationship with the measured outcome, as indicated by an effect size of 0.622.

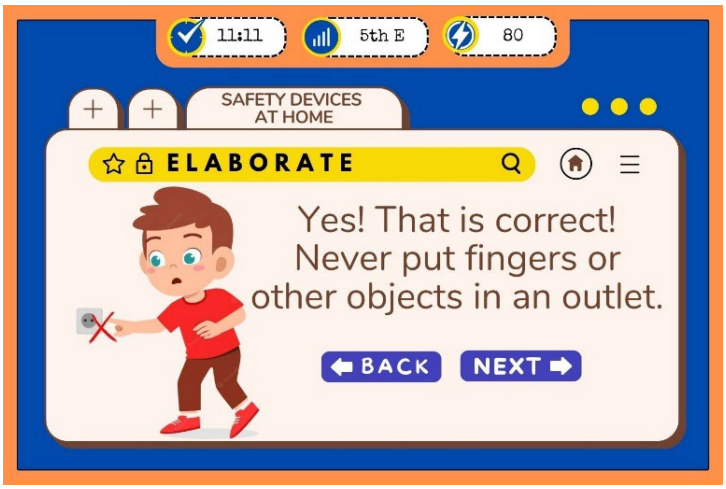

Figure 7. SIGMA Responsive Feedback

The systematic literature search reveals that the effect size of gamification studies that integrated responsive feedback is 1.463, while the effect size of gamification studies that did not integrate responsive feedback is 0.638. The findings indicate that including responsive feedback in gamification yields a more significant effect on the outcome than the absence of responsive feedback. Feedback in gamification is also incorporated in the Science-Inclusive Gamified Mobile Application to update students on their progress and performance, as shown in Figure 7. The students receive responsive feedback on whether their answer to a particular question is correct or not. Responsive feedback helps the students to avoid misconceptions. Also, responsive feedback is given to each student after considering their specific weaknesses and strengths. This kind of feedback provides students with insightful information about their development. A gamified mobile app provides users with dynamic feedback that highlights their achievements and suggests ways they might improve.

Figure 8. SIGMA Storytelling

Meta-analysis revealed that the utilization of storytelling in gamification resulted in a large effect size of 2.121. The findings indicate that the integration of storytelling within gamification yields notable effects on the measured outcomes. The utilization of storytelling in gamification is expected to exert a significant impact on various outcomes, such as user engagement, motivation, and learning, among others. The story integrated with SIGMA is about the Quest of Mr. Electro. The character should help all the powerhouses.

In comparison, the effect size observed in studies that did not integrate storytelling in gamification was determined to be 0.626, indicating a moderate effect size. The findings indicate that the inclusion of storytelling in gamification yields an increased impact on the measured outcomes in comparison to gamification without storytelling.

In light of the findings, the inclusion of storytelling in gamification yields a more significant intervention compared to the absence of storytelling in gamification. This inference is based on the analysis of the studies conducted. Using narrative or story is one method that the Science Inclusive Gamified Mobile Application (SIGMA) seeks to keep students engaged while they learn more about Science. In addition to having fun, the game could help students study more. There are tales spoken before and after any endeavor. The narrative style used in this research effectively conveys the essential facts students need to complete the assignments. Using a tale or narrative to hook players and give the game some meaning is crucial to gamifying an app.

Figure 9. SIGMA Timer

The results of the systematic literature search indicate that incorporating a timer in gamification has a relatively large effect size of 1.422. The findings indicate that incorporating a timer within gamification has a notable impact on its efficacy in attaining the intended results. Conversely, the effect size observed in research studies that did not integrate a timer within the gamification framework is 0.600, indicating a moderate effect. The findings indicate that including a timer in gamification may enhance its effectiveness compared to the absence of a timer, although to a relatively lesser degree. The research reveals that including a timer in gamification has a greater effect size than doing without, indicating that it is a more successful strategy to accomplish desired results. The incorporation of a time management feature in the SIGMA aims to assist users in meeting the high standards of work quality expected of them. The implementation of scheduled activities provides students with a structured framework that facilitates effective time management and enables them to concentrate on accomplishing individual tasks within the designated time frame.

It is no secret that the homework assignments pupils are given come with challenging deadlines. Students must learn the importance of time management in order to complete a wide range of tasks. The SIGMA has also incorporated a feature that helps users better manage their time while keeping in mind the high standards to which they are held in terms of the quality of the work they do. Students gain from scheduled activities because of the structure they give, which allows them to manage their time better and focus on completing individual tasks in the allotted time. Assignments, quizzes, and exams are all examples of timed work that students must complete within a limited time.

The significant difference in the Academic Performance of the students before and after using the Science-Inclusive Gamified Mobile Application (SIGMA)

Table 2 presents the data relative to the significant difference in students' academic performance before and after using the SIGMA. The pre-test mean was 10.15 out of 30 with a standard deviation of 2.798, and the post-test mean was 26.73 out of 30 with a standard deviation of 1.924. It is empirically evident that the pre-test mean is way lower than the post-test mean, which explicitly implies that the students were able to significantly improve their understanding of the competencies covered by the mobile application, particularly MELC 7-9 that discusses about electricity, after they utilized the Science-inclusive Gamified Mobile Application (SIGMA). Furthermore, through the computed values of standard deviation, it can be gleaned that the scores of the students are more dispersed during the pre-test and that the scores have become more proximal and compressed around the mean during the post-test.

Table 2. T-Test Result of Pre-test and Post-test Scores

Test Type	Mean	Standard Deviation	t-value	Sig. value	Interpretation	Decision to H_0
Pre Test	10.15	2.798	-52.138	0.000	Significant	Reject
Post Test	26.73	1.924				

Furthermore, the two means being compared garnered a t-value of -52.138, which is very large, indicating a highly significant difference between the two means being compared with a significant value of 0.000, which powerfully suggests that the null hypothesis can be confidently rejected in favor of the alternative hypothesis, which is "there is a significant difference between the pre-test and post-test scores of the students before and after using the Science-Inclusive Gamified Mobile Application (SIGMA)."

The researchers created a smartphone app with gamified components to get students interested in biology, including points, badges, and leaderboards. Students' understanding was measured before and after using the gamified mobile app, utilizing a pre-test and post-test approach. The study found a statistically significant improvement in test performance after intervention. Students' post-test scores were significantly higher compared to pre-test scores after utilizing the gamified mobile application, showing a beneficial impact on learning outcomes. According to the study's authors, this uptick may be traced back to the gamified mobile app's ability to engage students to take an active role in learning and boost their long-term memory retention.

Another study that looked into the impact of a gamified mobile app on primary school kids' mathematical learning was conducted by Anwar et al. (2020). The researchers wanted to increase students' interest in and enthusiasm for mathematics, so they created a smartphone app with gamified aspects like prizes and feedback. The study used a pre-and post-test design, and the results showed a statistically significant increase in student performance on the post-test compared to the pre-test.

The statistically substantial improvement in test scores from before to after using the gamified mobile app provides strong evidence for this conclusion. Improved learning outcomes may result from students being more motivated, engaged, and able to retain material gained through gamified mobile applications. The success of gamified mobile applications may hinge on several factors, including the nature of the program itself, the intended audience, and the learning goals being pursued. The long-term effects and transferability of gamified mobile applications in various educational settings require more investigation.

Mobile applications have evolved into an essential tool for improving student academic achievement. To improve student academic achievements, researchers have investigated several mobile application features such as learning analytics, gamification, and personalized learning. Alnasser and Alsaif (2020)

did a study in which they produced a mobile application called "My Study Life" with the goal of improving students' academic performance. Students could use the app to manage their time, set reminders, and establish study timetables.

According to the study, the application boosted students' time management abilities and academic achievement. Furthermore, Gikas and Grant (2013) conducted another study on the usage of mobile devices to improve student engagement and learning. The researchers discovered that interactive and multimedia aspects in mobile applications could boost student engagement. The study also emphasized the significance of mobile devices in enabling individualized learning experiences that meet the needs of individual students. In a study conducted by Echeverria and Romo (2020), the researchers created a mobile application called "Math Practice" to help pupils improve their arithmetic skills. Students received tailored learning experiences and feedback from the application. The application boosted students' math skills and raised their enthusiasm to learn, according to the study.

Moreover, Wu et al. (2021) investigated gamification in mobile applications to improve student academic performance. The researchers created a gamified mobile application called "iGingerbread" to help children learn English vocabulary. According to the study's findings, the gamified mobile application increased student involvement and motivation, resulting in better academic achievement.

The development of instructional materials is a crucial factor in improving students' academic performance. According to existing research, instructional materials that are well-designed and effective have been found to have a positive impact on learning outcomes, student engagement, and academic performance. Providing structured and organized content aligned with the curriculum objectives and learning goals is a hallmark of effective instructional materials. The presented materials exhibit a lucid and succinct style, enhancing the accessibility and comprehensibility of intricate concepts for students. According to Slavin (2020), instructional materials play a crucial role in facilitating students' systematic and efficient acquisition of knowledge and skills by providing a comprehensive and well-structured learning resource.

In addition, didactic resources provide diverse types of multimedia, including graphics, charts, and interactive features, that accommodate distinct learning modalities and inclinations. The incorporation of visual aids and multimedia elements has been shown to increase student engagement and improve comprehension of the material. According to Mayer's research conducted in 2019, the utilization of these materials presents avenues for engaging in active learning, fostering critical thinking, and enhancing comprehension, ultimately leading to better academic performance. Research findings indicate that the utilization of meticulously crafted educational resources has a favorable effect on the academic performance of students. According to Reimers and Chung (2019), students exhibit enhanced retention of information, heightened problem-solving abilities, and greater academic engagement when instructional materials are appropriately aligned with the curriculum and tailored to reinforce specific learning objectives.

The importance of collaboration among educators, instructional designers, and subject matter experts cannot be overstated, as it is essential to guarantee the accuracy, pedagogical soundness, and appropriateness of the materials for the intended audience. The findings suggest that the development of instructional materials that are adequately designed, aligned with the curriculum, and integrate diverse multimedia elements is imperative for enhancing students' academic performance. The aforementioned materials facilitate a systematic and captivating educational encounter for learners, promote enhanced comprehension, and reinforce self-directed learning. The development of effective instructional materials can be a valuable investment for educators seeking to improve student learning outcomes and academic achievement.

CONCLUSION

Enhancing Electricity Competencies: Identifying specific electrical competencies that need improvement reveals areas where students may struggle. Educators and curriculum creators can target these competencies and deliver a more successful and exciting learning experience for students by adding the Science-Inclusive Gamified Mobile Application (SIGMA).

Gamification for Academic Performance and Engagement: The incorporation of gamification elements into the development of the SIGMA application, such as leaderboards, badges, point systems, level advancements, and competition, has shown positive effects on academic performance, engagement, motivation, and metacognition in the context of Physics 8. This implies that gamification can be a helpful method for improving learning outcomes and increasing student engagement in science education.

Improved Academic achievement: The empirical evidence of a considerable improvement in comprehension of abilities covered by the SIGMA application, as evidenced by comparing pre-assessment and post-assessment results, demonstrates that the application has a favorable impact on student's academic achievement. This conclusion suggests that the SIGMA application could be a helpful tool for improving learning outcomes in the specific domain of electricity and potentially in other subject areas.

Design Aspects for Improvement: The development of themes based on respondent feedback, such as catering to all Science subjects, availability in app stores, offline accessibility, compatibility with various devices, and suitability for students with disabilities, indicates potential areas for further development and improvement of the SIGMA application. These design elements can improve the application's usability, reach, and inclusivity, making it more effective and accessible to a broader range of pupils.

These implications highlight the SIGMA application's potential to contribute to the fields of science education, instructional technology, and inclusive education by improving student competencies, engagement, motivation, and metacognition in electricity, as well as other subject areas. These insights can be used to refine and increase the application's influence in these areas through additional research and development activities. It would be quite intriguing to be able to duplicate the kind of intervention that was carried out in this study in longitudinal research since it would allow us to know the impacts of gamification over a prolonged length of time.

RECOMMENDATIONS

In light of the results and inferences drawn from the study, the researchers came up with several suggestions for further investigation, which are as follows: (1) Broaden the scope of the discussions that will be incorporated into the mobile application. (2) Ensure that the application continues functioning even when there is no internet connection. (3) Expand the scope of the survey so that it includes students who have a variety of disabilities. (4) Comparable research can also be conducted using experimental and controlled groups of participants. (5) Using the Science-inclusive Gamified Mobile Application, carry out a further phase of the research with participants from a variety of demographic groups. (6) The Science-included Gamified Mobile Application has the potential to be accepted and utilized by a more diverse group of students. (7) Some forms of training may be made available to teachers to improve their capacities in creating inclusive technology-based intervention tools. (8) Based on the findings of this study, institutions may develop plans and initiatives to address the challenges of inclusion in their communities.

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Xides Leonore P. Conwi is a faculty member of Rizal Technological University. Prior to teaching in RTU, she taught preschool and elementary students in an inclusive school in Mandaluyong. She finished her undergraduate studies at the University of Santo Tomas with a degree in Bachelor of Elementary Education major in Special Education. Currently, she is taking up a Master of Arts in Special Education major in Developmental Delays in Pamantasan ng Lungsod ng Maynila. She is a staunch advocate of inclusive education and firmly believes that no student should be left behind.