Research Paper

INSIGHT: Improving Numeracy Skills on Integers through e-Games and Hands-on Technology

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Abstract

Due to the school lockdown during the COVID-19 pandemic, students' numeracy skills declined. This was evident in the ERUNT conducted at Sagay National High School, which showed that among students in Grades 7 to 11, 40.77% are non-numerate in performing operations involving integers. Hence, the researchers conducted quasi-experimental classroom-based action research to propose a solution to this problem. The study was participated in by thirty-six (36) Grade 9 – Aquamarine students enrolled for the school year 2022 – 2023. The intervention used an offline e-game (Integer Saga) via immediate, hands-on technology (smartphones), which students used for fifteen (15) days in a controlled gameplay setting. Pre- and post-numeracy tests were conducted to determine the effectiveness of the intervention. The statistical tools used in the study are frequency and percentage, mean and standard deviation, paired t-test, and Pearson r. The results revealed an increase in the participants' numeracy in performing operations on integers after the intervention. A significant difference between the pre- and post-test results was observed, indicating that the intervention effectively increased participants' numeracy skills. Furthermore, the time spent using the application and the participants' post-test results were positively correlated. These results imply that the proposed intervention is effective in increasing students' numeracy skills, specifically in algebra. Therefore, it is recommended that this intervention be used to improve students' numeracy skills, specifically to develop mastery of performing operations on integers.

Keywords: *Enhanced-Regional Unified Numeracy Test (ERUNT), Gameplay, Numeracy, Numeracy Test, Offline E-Game*

INTRODUCTION

One component of mathematics education is honing students' numeracy skills. As cited by Tout (2020), numeracy, also called mathematical literacy, is the knowledge, skills, and attitudes that students need to use mathematics effectively in various real-world situations. It is a person's ability to use mathematical knowledge to make sense of the world around them.

In the Philippines, the Mathematics Framework for Philippine Basic Education (2011) included number and number sense as one of the mathematical content areas to be emphasized in the mathematics education curriculum. This content generally aims to enable Filipino students to read, write, and understand the meaning of order and the relationships among numbers and number systems, their operations, and the different strategies for computing and estimating (SEI-DOST & MATHTED, 2011).

However, despite being included in the implemented curriculum, the Philippines has been ranked lowest in mathematics and science among participating countries in various international assessments (Mullis et al., 2020; Schleicher, 2019; UNICEF & SEAMEO, 2020). This means that most Filipino students are still working towards mastering fundamental mathematical knowledge. Numeracy is one of the components that was assessed by these assessments.

With the educational gap left by the pandemic, academic institutions worldwide have

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adopted the digitalization of mathematics education to improve students' numeracy. Several studies have been conducted to establish the benefits of digital technology, specifically in learning gamification. For instance, Wang et al. (2022) highlighted in their research that digital games can promote and develop students' learning and have been shown to provide greater learning gains.

This is supported by Jaafar et al. (2022), who emphasized that the use of technology can significantly improve teaching and learning outcomes and provide teachers with opportunities to enhance their teaching, productivity, and efficiency. However, common to this study is the focus on the effectiveness of digital technology in teaching mathematics as a whole, with less emphasis on the subject's sub-disciplines as taught in the K-12 curriculum.

Hence, grounded in experiential learning and digital game-based learning theories, the researchers aimed to explore the effectiveness of using e-games and hands-on technology as a potential intervention to enhance students' numeracy skills, specifically their mastery of operations on integers. In this study, hands-on technology refers to the active use of readily available digital devices, such as smartphones, that learners can use immediately to interact with game-based interventions through direct manipulation. The proposed intervention focuses on the effectiveness of an offline gaming application in aiding students' mastery of operations on integers, a fundamental concept in algebra.

This study contributes to the existing literature by providing empirical support for experiential and digital game-based learning theories in the context of innumeracy development and algebra readiness within basic education. It is also beneficial for basic education institutions because it proposes a possible intervention that can maximize the use of technology to enhance students' numeracy skills, thus increasing their mathematics achievement in algebra.

Mathematics teachers will also gain from this study, as the proposed intervention can serve as a basis for classroom interventions or teaching strategies for the subject. Finally, this is significant for students because it gives them an overview that they can use available hands-on technologies (smartphones) and offline gaming applications to develop their numeracy skills.

LITERATURE REVIEW

The following literature explores the use of technology in education (digitalization) and its relationship to students' numeracy. The literature also explores existing studies on sex disparities in mathematics learning, specifically in numeracy. This literature laid the theoretical and empirical grounds for the proposed intervention, which integrates e-games through hands-on technology to enhance students' mastery of integer operations.

Technology in Numeracy Education

Technology is seen to have a strong impact on the field of education. If used responsibly and correctly, technology can be a useful instructional tool in the classroom. The recent onslaught of the COVID-19 pandemic served as a catalyst for further use of technology to make education accessible remotely. The use of digital learning modalities has greatly expanded during the pandemic. As such, students and teachers alike have explored various digital technologies and available software that can aid learning in the comfort of their homes (Alabdulaziz, 2021). However, the use of such technologies, or the digitalization of education, remains a subject of debate, as current studies yield mixed results regarding their effectiveness.

Some studies have found that students who are engaged in gameplay are positively associated with increased academic performance, specifically in numeracy and reading (Islam et al., 2020; Fabian et al., 2018). The use of technology in classroom instruction has also been shown to enhance students' critical thinking skills, which is one of the goals of mathematics education (Sukma & Priatna, 2021). This involves using the Internet and various software applications installed on computers, smartphones, and other digital devices to connect with classmates and teachers (Rodriguez, 2020). Moreover, collaboration and peer-to-peer mentoring can be fostered among students when teachers use a game-based learning approach to teach mathematics (Kefalis & Drigas, 2019).

On the other hand, studies have also shown that unstructured use of technology in classroom instruction negatively impacts learning, thereby worsening students' academic performance (Genlott & Grönlund, 2016). Teachers often overestimate students' ability to learn the technology on their own and assume they will eventually learn it. However, many students struggle to grasp how to use the integrated technology, thereby hampering the learning process (Viberg et al., 2020). Hence, it is recommended that teachers be trained to integrate technology to enhance the teaching-learning process (Carstens et al., 2021).

Furthermore, with recent technological advancements, chatbots and AI have now been introduced in the classroom. Wardat et al. (2023) emphasized that although AI (ChatGPT) can provide basic mathematical knowledge to its users (in this context, students), it still lacks a deep understanding of certain areas, such as geometry and algebra, making it unreliable without educator supervision.

The above-mentioned studies signify that technology can enhance numeracy when it is intentionally designed, structured, and aligned with a clear purpose. These support the proposed intervention, which employs a guided and offline digital learning environment to ensure that technology is accessible and can support, rather than distract, students as they learn integer operations.

Gamification and Numeracy Development

With the advent of technology in the educational landscape, educators are now exploring gamification to increase students' motivation to learn. Gamification, in the context of education, refers to "the use of game-design elements or mechanisms in non-game contexts to promote expected behavior" (Luo, 2022). This comprises adapting game frameworks, such as goal-setting, task visualization, challenges, competitions, and reward systems, to promote greater student engagement.

Using this teaching method still requires teachers to play an active role in facilitating learning (Kang & Recard, 2023). Teachers should plan a proper timeframe for implementing the gamified activity, give clear instructions, and constantly check students' progress. Although it is currently used by educators, several studies show mixed results regarding its effectiveness in teaching.

Yığ and Sezgin (2021) reported that educators had been exploring digital gamification in mathematics education. The purpose of adopting a gamified approach to learning is primarily to encourage motivation and engagement among students. This has positively impacted the students' problem-solving skills and mathematics performance. This was supported by Malabayabas et al. (2024), who stated that a gamified learning application can help students to enhance their academic performance and influence their satisfaction with mathematics education.

On the contrary, regarding the implementation of a game-based intervention in the classroom, Tokac et al. (2019) stressed that, despite the observed positive impact on mathematics achievement, the duration of exposure to the intervention has little effect on students. The research conducted by Lee et al. (2023) suggests that the effects of gamification vary among students. More favorable responses from high-performing students in mathematics were recorded for gamified instruction. However, its impact is minimal for those who are low-performing.

These mixed findings reveal inconsistencies in gamification research, often attributed to differences in instructional design, learner readiness, and alignment with specific mathematical design. The intervention addresses these limitations by focusing on a narrowly defined numeracy skill-operations on integers-and by incorporating structured use and progression, immediate feedback, and close monitoring to support learners.

Gender Disparities in Mathematics Achievement

Throughout history, various stereotypes about mathematics have been a common topic of discussion. As Chua (2023) emphasized in his study, older literature suggests that mathematics, as a discipline, is perceived as more masculine. Emphasis on logic and precision, which are fundamental skills in learning mathematics, is attributed more to males than to females.

The trend in gender disparity and its relation to numeracy, or mathematical achievement, varies across countries and cultures. For instance, in some contexts, studies emphasized that one's ability to learn mathematical concepts and skills is not determined by one's sex. This means that males and females are equally capable in all aspects of learning, particularly intellectually (Daramola et al., 2022).

However, further study suggests that, despite similar performance between the sexes at the preschool and elementary levels, sex disparities in mathematics achievement become more apparent at the high school and college levels. In the context of state-wide standards-based examinations, boys are seen to outperform girls (Ganley, 2018; Räsänen et al, 2021). On the other hand, girls outperform boys in terms of school grades, which is more directly related to the mathematics curriculum adopted by the academic institution (Ganley, 2018, as supported by De Guzman, 2022).

In this study, gender disparity is treated as a secondary variable to provide a much more thorough understanding of how the intervention affects numeracy outcomes across gender. By doing so, the equity of the learning gains from the intervention can be examined, thus informing broader implications for inclusive mathematics instruction.

RESEARCH METHOD

Research Design

The researchers used a quasi-experimental classroom-based action research design. Quasi-experimental in the sense that the researchers aim to determine the causality or effect of an independent variable on a dependent variable using a non-randomized sampling method. In this study, the researchers determined the effect of the intervention: the use of an offline e-game (Integers Saga) on the numeracy (performance rate) of the participants.

The participants were selected using purposive sampling, as the researchers identified the section with the greatest number of non-numeric responses from the pre-test. Although purposive sampling allowed targeted intervention among the grade level with the greatest number of non-numerates, it presents a limitation in terms of potential sample bias and limited external validity.

It is also classroom-based action research, as it was conducted in response to a classroom problem. In this research, the problem was identified based on the class's performance on the Enhanced-Regional Unified Numeracy Test (E-RUNT), which revealed that 47.22% of Grade 9-Aquamarine students are non-numerate. Hence, an intervention was introduced, and the results were interpreted only within the specific classroom context in which the study was conducted.

Participants of the Study

The study was participated in by thirty-six (36) Grade 9-Aquamarine students of Sagay National High School enrolled for the academic year 2022-2023. The participants were selected based on the results of the Enhanced-Regional Unified Numeracy Test (E-RUNT). First, the researchers identified the grade level with the highest percentage of non-numerates: Grade 9 (40.77%). The researchers then determined that the section with the highest percentage of non-numerates was Grade 9-Aquamarine (47.22%). This sampling method is conducted to ensure that the effect of the intervention can be tested clearly.

Data Instrument

The instrument used to determine participants' performance rate before the intervention (pre-test) is a standardized numeracy test recommended by the Department of Education – Region VI (2022). The test aims to assess the student's competency in performing operations on integers. The numeracy test is divided into four (4) categories: addition, subtraction, multiplication, and division. Each test consists of 10 items. A parallel test was developed to assess students' performance after the intervention.

Intervention

The intervention introduced to the participants in this study used an offline e-game, Integer Saga. This educational application, developed by JCBM, requires only 7.9 MB of storage space. It requires no internet connection and has an intuitive navigation panel that allows students to access the application easily.

The main feature of the application is that it trains students' ability to perform operations on integers through gameplay. The application offers five (5) gameplays: addition, subtraction, multiplication, division, and random. For each gameplay session, the student can choose one of three (3) difficulty levels: easy, average, or hard. For the easy level, the student is given single-digit numbers to solve and is given twenty (20) seconds. For the average round, the students are given a mix of single- and double-digit numbers to solve and are given fifteen (15) seconds. For the hard level, the students are given larger double-digit numbers to solve and are only given ten (10) seconds. Each round consists of ten (10) questions, and students can choose either to be given choices or to type the answer.

Every day, before their mathematics class begins, the participants are asked to use the application for 5 minutes. Due to a shortage of devices, the participants were asked to form dyads. Each pair is asked to take turns using the application while the researchers record each other's progress. A timer is provided to ensure that each student maximizes the given five (5) minutes. To mitigate potential bias from shared devices and pairing, close researcher supervision was maintained throughout the sessions. Students were required to take turns using the application with a clearly specified and equal duration of time. Each day, the researcher assigns a specific game for the student to play (e.g., addition, subtraction, multiplication, or division). Random gameplay is given at the end of every week.

The researchers predetermined a gameplay setting that would match the difficulty and the time to be spent on each test under the ERUNT, which is two and a half (2.5) minutes per operation. For the first 5 days of implementation, the application was set at an easy level where they were to type their answers. This is to help students get familiar with how the application works. For the next ten (10) days, the application is set at an average level where they are to type their answers. This setting matches the actual ERUNT assessment in both difficulty level and time.

Data Gathering Procedure

This study involved Grade 9 – Aquamarine students enrolled at Sagay National High School for the 2022-2023 school year. First, the school conducted the ERUNT on June 5, 2023. The result for the chosen participant in this study from the initial assessment was treated as their pre-test result. Next, the researchers implemented the intervention for fifteen (15) days, starting from June 13 until July 3 of the same year. The participants were also asked to record the amount of time they use the application outside the period when they are supervised by the researcher. To validate the accuracy of these records, students tracked their usage daily and submitted their recorded time to the researcher each day for consistency checks and monitoring of irregular entries. The researcher collects their records at the end of every week. After the intervention, a post-test was administered to assess students' performance, and a parallel test was administered two weeks later, specifically on July 17.

Data Analysis

In this study, the researchers used various statistical tools to analyze the data gathered. All of which were run using the IBM SPSS Statistics Version 20. To determine the profile of the participants and their numeracy rates, the statistical tools employed are frequency and percentage. Students who got a total score of thirty (30) and above from the four (4) tests are considered numerates; otherwise, non-numerates. To determine the difference between participants' pre-test and post-test results, the researchers used a paired t-test. To determine the correlation between their post-test results and the time spent using the application, the Pearson Product-Moment Correlation Coefficient (Pearson r) is used.

Ethical Consideration

The researcher ensured that the data gathered from the respondents were kept confidential in adherence to the Data Privacy Act of 2012 in the Philippines.

FINDINGS AND DISCUSSION

This study generally aims to determine the effectiveness of using an offline e-game (Integers Saga) and hands-on technology (smartphones) as an intervention to enhance the numeracy rate among Grade 9 – Aquamarine students of Sagay National High School who were enrolled for the academic year 2022 - 2023. Specifically, it aims to determine the following information.

Profile of the Respondents

Table 1 shows that 16 (44.44%) of the participants are male, while 20 (55.56%) are female. As the results show, there are more female participants than male participants in the study.

Table 1. Profile of the Participants

Sex	Frequency	Percentage
Male	16	44.44
Female	20	55.56
Total	**36**	**100.00**

Pre-test Numeracy Rate

Table 2 shows that, based on the pre-test, 19 (52.78%) of the participants are numerate. Among them are 7 (19.44%) males and 12 (33.33%) females. The result also revealed that 17 (47.22%) of the participants are non-numerate. Included in this number are 9 males (25.00%) and 8 females (22.00%) participants. The result shows that, overall, there are more numerates than non-numerates among the participants. However, the gap in their percentage is narrow. When grouped by sex, the findings revealed that more females are numerate than males.

The narrow gap between the numbers of numerates and non-numerates among the participants can be taken as a manifestation of the pandemic's negative impact on education. This is consistent with what UNICEF (2022) and The Royal Society Advisory Committee on Mathematics Education (2020) stated, which emphasized that school lockdowns caused students to lose or fail to develop their numeracy skills. As the results show, females perform better on assessments based on the implemented curriculum.

In terms of sex, the results revealed that females, prior to the intervention, outperformed males on standardized assessments. This is parallel to the result of De Guzman (2022), which states that in terms of mathematics achievement, or in this study, numeracy, females tend to outperform boys in tests that are based on the direct influence of the implemented curriculum of the academic institution.

Furthermore, the result presented in this table runs counter to the claim of Räsänen et al. (2021), which stressed that males perform better than females in standardized assessments. Females are found to have more numeracy than males. This means that females are also capable of achieving higher scores on standardized tests. As Daramola et al. (2022) stressed, females are also capable of all aspects of learning, especially intellectual ones, including numeracy.

Table 2. Pre-test Numeracy Rate as a Whole and when Grouped According to Sex

Sex	Numerates		Non-Numerates	
	f	%	f	%
Male	7	19.44	9	25.00
Female	12	33.33	8	22.00
Total	**19**	**52.78**	**17**	**47.22**

Note*:* Numerates and non-numerates are identified as follows: above or equal to 30 total scores (numerates); less than 30 total scores (non-numerates).

Post-test Numeracy Rate

Table 3 shows that, based on the post-test results, the number of participants increased to 26 (72.22%). This includes 10 (27.78%) males and 16 (44.44%) females. On the other hand, the number of non-numerates decreased to 10 (27.78%), comprising 6 males (16.67%) and 4 females (11.11%).

Based on the results presented in the table, there is a 41.18% decrease in the number of non-numerates between the pre-test and post-test. When sex is considered, the same trend is observed for both males (33.33% decrease) and females (50.00% decrease). This widened the gap between the percentages of numerates and non-numerates among the participants.

This result revealed that after the intervention, participants' numeracy improved. This aligns with the study by Fabian et al. (2018), which emphasized that using game-based activities in mathematics instruction could improve students' numeracy skills, thereby increasing the number of numerate participants. Moreover, as Genlott and Grönlund (2016) implied, structured use of technology, as in the implemented intervention, could positively increase academic performance – in this case: numeracy.

Furthermore, the increase in the numeracy rate is observed in both sexes. As Kefalis and Drigas (2019) noted, game-based instruction promotes collaboration and peer-to-peer mentoring, as observed during the intervention. Motivation from their partners, as permitted by the interventions set up, might also be a driving factor.

Table 3. Post-test Numeracy Rate as a Whole and when Grouped According to Sex

Sex	Numerates		Non-Numerates	
	f	%	f	%
Male	10	27.78	6	16.67
Female	16	44.44	4	11.11
Total	**26**	**72.22**	**10**	**27.78**

Note*:* Numerates and non-numerates are identified as follows: above or equal to 30 total scores (numerates); less than 30 total scores (non-numerates).

Difference Between Pre-test and Post-test Results

This study also aims to determine whether there is a significant difference between participants' pre-test and post-test results on the numeracy test after the implementation of the intervention.

As shown in Table 4, the participants' pre-test and post-test results differ significantly ($t = -4.28$, $p = 0.000$). When the sex of the participants is considered, there is also a significant difference between pre-test and post-test results for males ($t = -3.64$, $p = 0.002$) and females ($t = -2.51$, $p = 0.021$).

As the results revealed, the participants' post-test performance differed significantly from their pre-test results. Earlier results suggest higher performance on the post-test. This means the applied intervention is sufficiently effective to significantly increase students' performance. Additionally, this significant difference in pre- and post-test results is reflected when the participants' sex is considered. This suggests that the intervention is effective regardless of participants' sex.

This finding agrees with the studies by Fabian et al. (2018) and Islam et al. (2020), which found that game-based instruction and interventions can significantly improve students' numeracy. Moreover, this is consistent with studies by Yığ and Sezgin (2021) and Malabayabas et al. (2024), which found that using gamified tools in mathematics education can improve performance.

This result demonstrates the viability of the applied intervention in improving students' numeracy and algebra performance. As reflected in the results, the intervention affects both sexes, thereby ensuring its acceptability despite sex differences. Thus, this provides mathematics teachers with a readily available game-based intervention to enhance their students' numeracy, supporting both male and female learners. Mathematics educators may leverage this intervention to address gender-based differences in learning preferences, thereby promoting equitable learning opportunities in numeracy-focused mathematics instruction.

Table 4. Difference Between Pre-test and Post-test Results

Test	Sex	t	df	p
Pre-test and Post-test	Male	-3.64	15	0.002
	Female	-2.51	19	0.021
	As a Whole	**-4.28**	**35**	**0.000**

Note: If $p \leq 0.05$, then reject H_0

Relationship between Time Spent and Post-Test Results

Finally, this study investigated whether there was a significant relationship between participants' time of exposure to the intervention and their post-test results. As indicated in Table 5, when taken in its entirety, there is a significant relationship between participants' time spent using the application and their post-test results ($r = 0.76$, $p = 0.000$). Considering sex, males ($r = 0.71$, $p = 0.002$) and females ($r = 0.80$, $p = 0.000$) also showed a significant relationship between time spent exposed to the intervention and post-test results.

The results in this table indicate that the duration of exposure to the game-based intervention (Integers Saga) for the students is significantly correlated with their post-test results. This means that the longer they are exposed to the application, the higher the effect on their numeracy test results. The same trend is observed when the participants' sex is considered.

This finding contradicts the claim by Tokac et al. (2019) that the effect of the length of game-based intervention on mathematics achievement is minimal. As the results suggest, the time students spend using the application positively correlates with their post-test results. Longer exposure to the application provides students with more opportunities to practice their numeracy skills and explore more advanced levels of difficulty, thereby attaining a higher level of mastery.

Table 5. Relationship between Time Spent and Post-test Results

Test	Sex	N	r	p
Time Spent and Post-Test Result	Male	16	0.71	0.002
	Female	20	0.80	0.000
	As a Whole	**36**	**0.76**	**0.000**

Note: If $p \leq 0.05$, then reject H_0

Despite the positive findings of this study, several limitations must be considered when interpreting the results. First, the sample size was limited to thirty-six (36) Grade 9 students from a single section, which may restrict the generalizability of the findings to other contexts, grade levels, or student populations. Second, the intervention's implementation is relatively short (15 days). While there are significant gains, this timeframe may not fully capture the long-term effects of sustained exposure to the intervention. Lastly, access to technology may be limited, as device availability requires students to share smartphones, potentially affecting individual engagement levels despite close supervision and structured turn-taking.

Given these limitations, future research is recommended to replicate the study using a larger, more diverse sample across multiple grade levels or schools to strengthen external validity. Longitudinal studies may also be conducted to examine the effectiveness of the intervention when applied over a longer period. In addition, future studies may explore other e-games targeting other subdomains of mathematics.

CONCLUSIONS

According to the participants' profiles, the majority of Grade 9 – Aquamarine participants are female. Before conducting the intervention, the gap between the percentage of numerate and non-numerate participants is narrow. Despite the participants being in high school, the narrow gap between the numbers of numerates and non-numerates can be interpreted as a manifestation of the pandemic's negative impact on mathematics education. More students are behind in the expected mastery of the competencies required at their current year level. This is alarming since algebra, specifically numeracy skills in dealing with operations on integers, is a fundamental skill needed to learn higher mathematical concepts.

In terms of sex, the results showed that females outperform males in numeracy skills. Hence, this study supports earlier studies that emphasized females' ability to learn and master mathematics, which is not inferior to that of males. The country's strong adherence to Education for All (EFA), which provides equal opportunity for both men and women to access free education, contributes greatly to the result. Women are now given an avenue to hone their mathematical potential.

After the intervention was implemented, the students' numeracy rate and performance levels showed visible improvement. Overall, the gap between the percentages of numerate and non-numerate participants widened. Both males and females showed a decrease in the number of non-numerates. On the other hand, the participant's performance rate increased significantly compared to their pre-test result. As a whole, the class showed a very high level of performance. The same trend was observed when participants were grouped by sex, with the effect more evident among female respondents.

The study also revealed a significant difference between participants' pre- and post-test results on the numeracy test, thus rejecting the initial hypothesis. The difference in scores demonstrates that the applied intervention is effective in helping students attain a higher level of numeracy, specifically in operations with integers. Aside from this, the use of technology and game-based interventions in the classroom, when managed correctly, can also foster peer-to-peer mentoring, which provides extrinsic motivation for students. Thus, this research supports the perceived benefits of digital technology in mathematics learning. Gamification of lessons greatly increases students' interest in the subject, resulting in higher academic gains.

Finally, the duration of the participants' usage or exposure to the application or intervention is positively correlated with their post-test results. The longer students spend using the application, the more they can practice their numeracy skills. With this, the research opposes the claim of earlier studies that prolonged exposure to technology would hamper learning.

From the results, we can conclude that consistent, longer practice with the aid of the intervention would eventually make students familiar with the rules for performing operations on integers, thereby cultivating mastery of the concept. They can explore different game modes and levels of difficulty, offering new challenges and experiences.

The implication of this study is that it proposes an intervention designed to enhance students' numeracy skills in algebra, specifically in operations on integers, using digital technology. As highlighted in the results, the intervention is proven to be effective and has a positive impact on students' numeracy development. Furthermore, the application used in the intervention requires minimal storage space and no internet connectivity, thus ensuring accessibility even in public schools. While these findings are promising, they must be interpreted with caution due to limitations such as a small sample size, a short intervention duration, and the study's classroom-specific context.

Despite these limitations, the results offer meaningful implications for school-level decision-making and instructional planning in mathematics education. Schools may adopt structured offline game-based interventions as part of their numeracy remediation programs. More broadly, the study's improvement in numeracy underscored the role of foundational mathematics in supporting student success not only in mathematics but also across STEM disciplines.

Having a strong foundation in mathematics contributes to better preparedness for higher-level mathematics. Hence, interventions that enhance numeracy through experiential and technology-supported learning will not only benefit mathematics instruction but also support broader STEM education goals by fostering analytical thinking, computational fluency, and learner engagement.

LIMITATION & FURTHER RESEARCH

The following limitations were observed during the study and form the basis for directions for future studies.

1. The duration to conduct the intervention is limited to fifteen (15) days because the school year is ending. Future studies can test the intervention's effectiveness over a longer duration to establish more reliable results by conducting longitudinal studies that examine whether learning gains are sustained.
2. The intervention was only conducted at one grade level, which was identified to have the greatest number of non-numerates based on the set standard. Future studies can employ the same intervention across multiple grade levels or schools to determine whether the results are consistent across more diverse samples.
3. The intervention focused primarily on increasing numeracy skills among students, specifically in operations on integers under algebra. Future studies can identify additional offline interactive applications that address students' difficulties in other sub-disciplines,

such as geometry, statistics and probability, measurement, and number sense.

4. The study purely employed quantitative means to determine the effect of the intervention on the numeracy of the participants. Future studies may include simple qualitative approaches such as short student reflections, learning journals, and brief teacher interviews to gain a more holistic insight into learners' experiences, motivation, and perceptions of the intervention.

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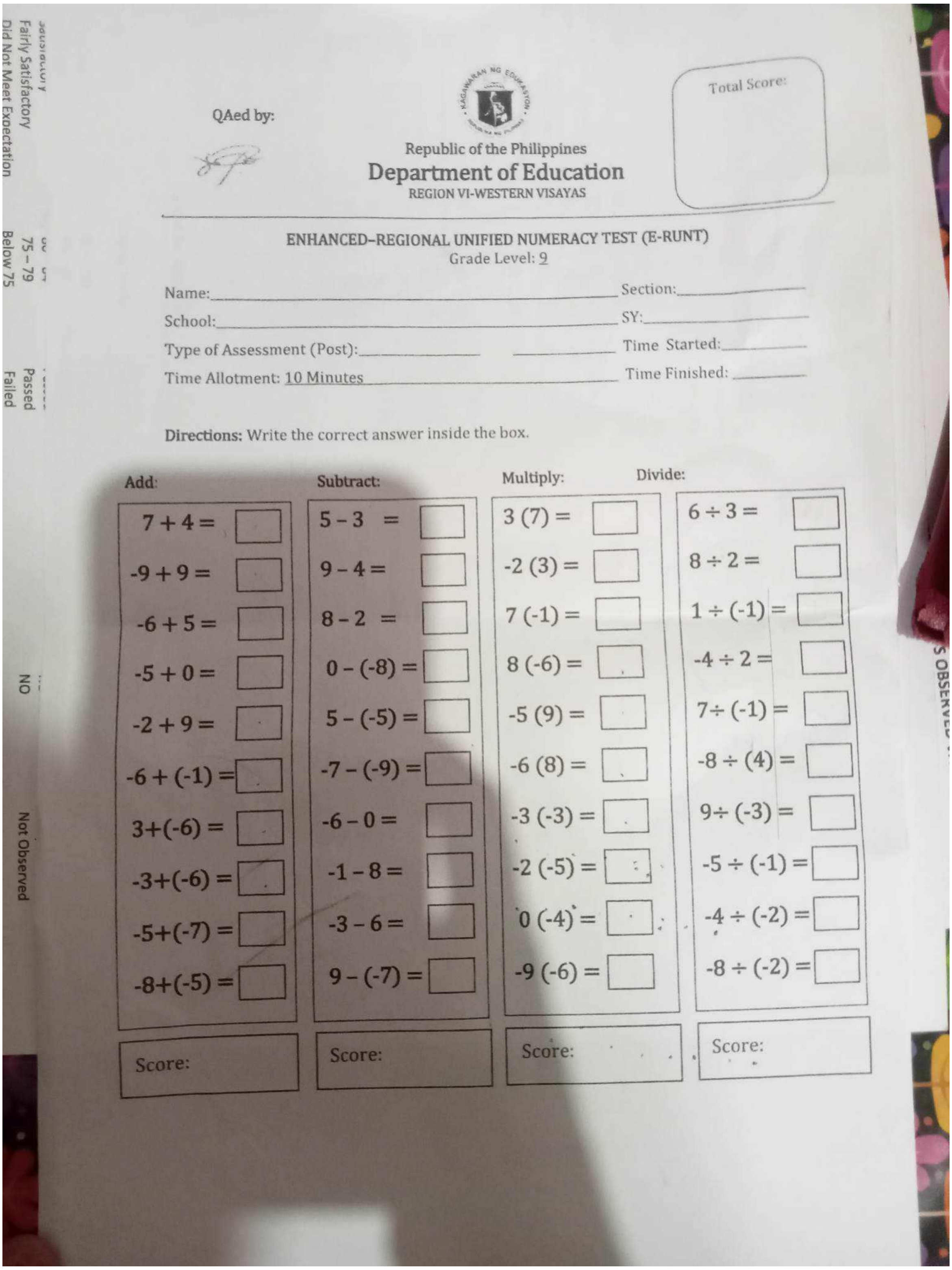
APPENDICES

Appendix A: Research Instrument



QAed by:

Republic of the Philippines
Department of Education
REGION VI-WESTERN VISAYAS

Total Score:

ENHANCED–REGIONAL UNIFIED NUMERACY TEST (E-RUNT)
Grade Level: 9

Name:__________ Section:__________

School:__________ SY:__________

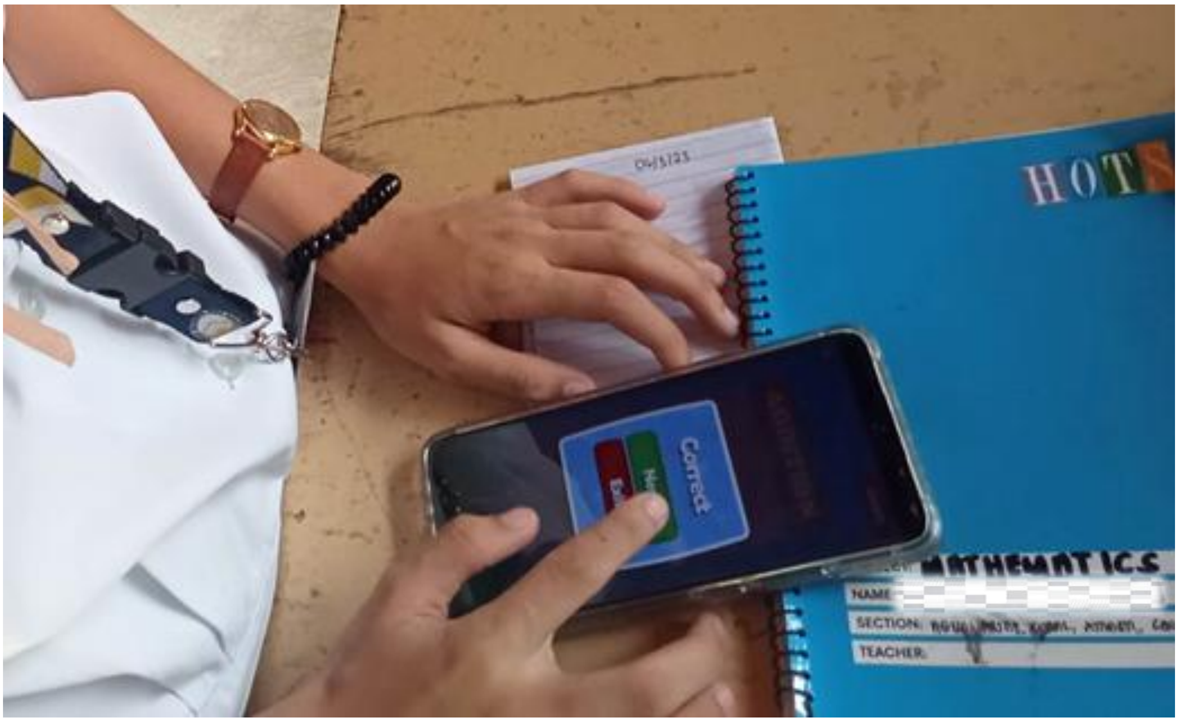
Type of Assessment (Post):__________ Time Started:__________

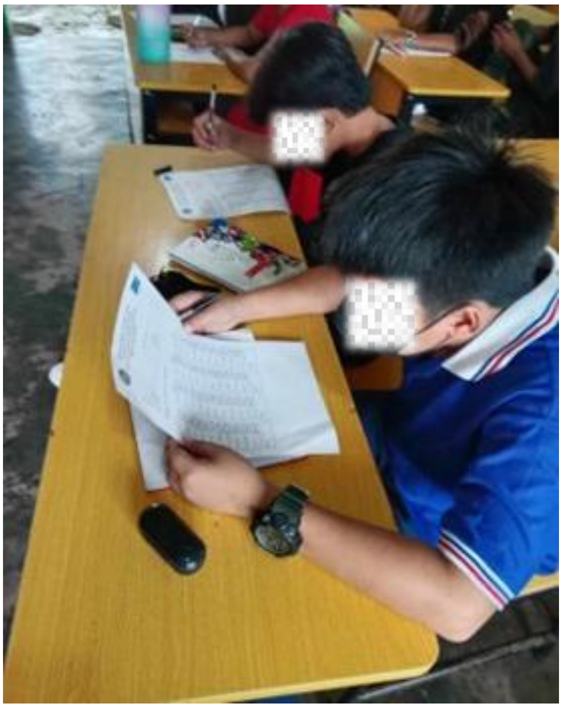
Time Allotment: 10 Minutes Time Finished:__________

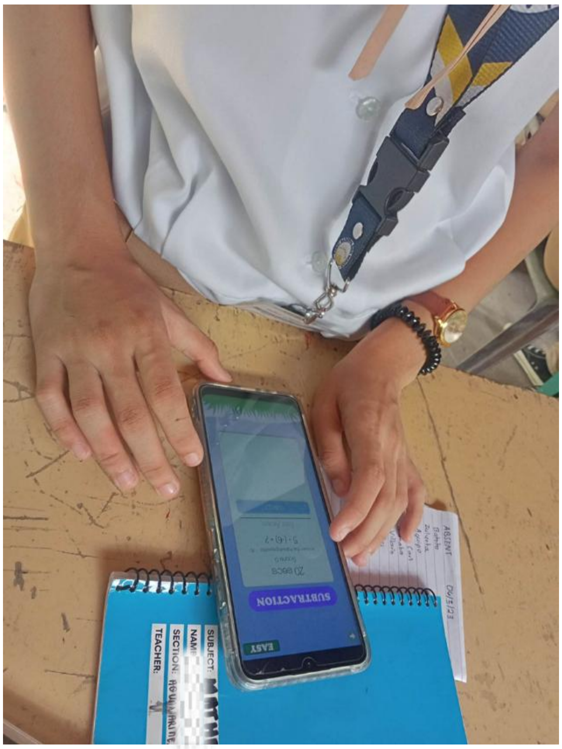
Directions: Write the correct answer inside the box.

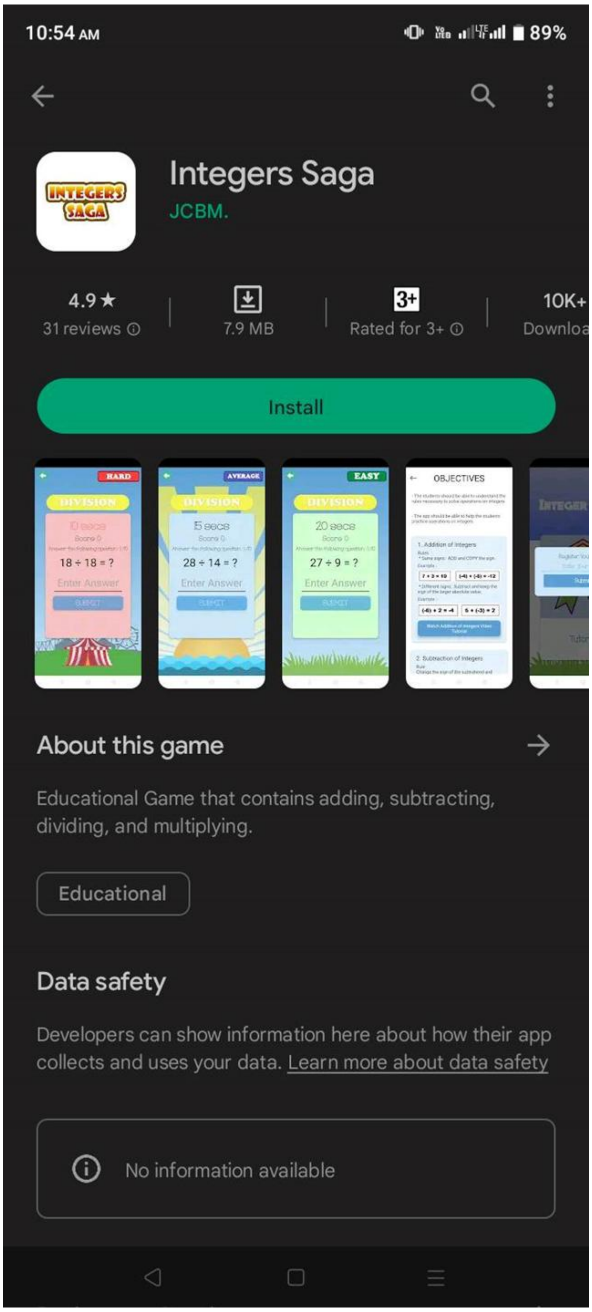
Add:	Subtract:	Multiply:	Divide:
7 + 4 =	5 – 3 =	3 (7) =	6 ÷ 3 =
-9 + 9 =	9 – 4 =	-2 (3) =	8 ÷ 2 =
-6 + 5 =	8 – 2 =	7 (-1) =	1 ÷ (-1) =
-5 + 0 =	0 – (-8) =	8 (-6) =	-4 ÷ 2 =
-2 + 9 =	5 – (-5) =	-5 (9) =	7÷ (-1) =
-6 + (-1) =	-7 – (-9) =	-6 (8) =	-8 ÷ (4) =
3+(-6) =	-6 – 0 =	-3 (-3) =	9÷ (-3) =
-3+(-6) =	-1 – 8 =	-2 (-5) =	-5 ÷ (-1) =
-5+(-7) =	-3 – 6 =	0 (-4) =	-4 ÷ (-2) =
-8+(-5) =	9 – (-7) =	-9 (-6) =	-8 ÷ (-2) =
Score:	Score:	Score:	Score:

Appendix B: Documentations








10:54 AM
89%
Integers Saga
JCBM.
4.9★
31 reviews
7.9 MB
Rated for 3+
10K+
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About this game
Educational Game that contains adding, subtracting, dividing, and multiplying.
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