Math Basics Pro With 5Is Learning Path Integration in Mastering Algebra Prerequisites

Sarah Jane M. Catacutan[1], Allan Jay S. Cajandig[2]

[1]Tampakan National High School, Philippines

[2]Sultan Kudarat State University, Philippines

DOI: https://doi.org/10.51244/IJRSI.2025.12040025

Received: 07 April 2025; Accepted: 16 April 2025; Published: 01 May 2025

ABSTRACT

Learning mathematics is a spiral process. Students often struggle to master the prerequisites, which are essential before learning the complex topics in algebra. This study aimed to address this problem by developing an Android application named MathBasics Pro, integrating the 5Is learning path, which aims to bridge the mathematics learning gaps caused by the pandemic and other factors. A one-group pretest-posttest quasi-experimental design was employed by purposely choosing 78 Grade 9 students of Tampakan National High School to use the application for drill practice on their mobile phones. Based on experts' validation results, the Android application is excellent in terms of its appropriateness, appeal, content, instructional, and technical quality. The students also rated the application as very satisfactory in terms of its usability and user experience. The students performed below expectations in the pretest before using the application. However, in the posttest, students' scores increased significantly and became very satisfactory as computed using the z-test. Furthermore, the students' mean scores in their drill practice using MathBasics Pro are also very satisfactory. The Pearson r correlation was used to see if there was a link between the scores on the drill practice application and the performance on the posttest. There was no significant link between the two variables, which means that students may make mistakes during drill practice but eventually get better, as shown by the posttest. The study recommends conducting more research to assess the efficacy of Android applications for mathematical drill practice.

Keywords: Drill Practice, 5Is Learning Path, Algebra Prerequisites, Android application, Mathematics

INTRODUCTION

Mathematics plays a crucial role in all aspects of man's life. Ironically, most learners worldwide perceive mathematics as one of the most challenging subjects to master. One of the areas of mathematics that students from elementary school through high school must know is algebra. Students who have a solid grasp of algebra can better comprehend other mathematical concepts and subjects. The concept of algebraic prerequisites contributes to students' misconceptions about algebra. Numerous studies have revealed that students worldwide struggle to grasp fundamental mathematical concepts, which has an impact on their performance when they advance to higher learning levels. Basic ideas may not be mastered by learners, or they may be forgotten due to infrequent use between courses. Additionally, students frequently fail in advanced math subjects, possibly because of their inability to grasp prerequisite ideas.

Globally, educational systems struggle to prepare students for advanced mathematics. In many nations, higher education students struggle with basic arithmetic abilities, which hinders their capacity to study advanced math.

The COVID-19 pandemic has affected Philippine math education, particularly students' knowledge of basic math concepts. Students struggled to adapt to self-learning modules in modular distance learning (MDL), especially in mathematics. Reference [2] discovered that some students struggled with time management and household responsibilities, resulting in inadequate math module submissions. Filipino students performed significantly lower in mathematical numeracy than students in other countries in 2018, with the majority falling below the baseline ability level [26]. Students' poor arithmetic skills make advanced math concepts difficult to grasp.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Reference [2] also suggested focused interventions to reduce gaps in education and enhance Philippine students' arithmetic skills. DepEd aims to improve Filipino students' worldwide large-scale exam scores and recover from COVID-19 school closures and disruptions. Under the MATATAG agenda, the National Learning Recovery Program (NLRP) accelerates learning to make up for learning losses. The National Mathematics Program is one of four MATATAG agenda components. It improves math and numeracy across grades.

Many math teachers in the Division of South Cotabato encounter challenges when teaching complex mathematical subjects, particularly those that require mastery in fundamental concepts like integers and fractions. The math teachers in the Tampakan District said that most of the topics in the least learned competencies needed a strong background in fractions and integers, along with operations on rational algebraic expressions and quadratic equations. Furthermore, limited research in the local area has been conducted on the importance of mastering algebra prerequisites in learning more complex math branches here in South Cotabato.

This gap typically hinders understanding of increasingly advanced mathematical topics. Learning using technology, especially mobile phones, may help solve the problem. Reference [1] studied Filipino high school students' mobile device academic use. The study found that mobile phones increase academic performance and learning. Mobile learning interventions enhanced third-grade math competence [17]. The study also found out that continuous practice with mobile technologies improves fundamental numeracy skills. These studies indicate that mobile technology can help students learn fundamental math and transition to advanced math. Teaching students to critically evaluate fractions and integers is tough. Teachers must innovate hard. One innovative method is mobile learning. Most students use phones in class, so utilizing them to understand fractions and numbers might assist. This is the reason that motivates the researcher to use the most frequently used device among students, their cellphones, to assist them in mastering the concepts of integers and fractions in the form of a mobile game. One of the teacher-research projects is the MathBasics Pro Android app, which fosters interest and engagement in learners during NMP sessions by making mathematics enjoyable and game-like.

This research focuses on the development of an Android application named MathBasics Pro, which includes drills and practice topics involving integers and fractions, the prerequisite basic math concepts in learning algebra [29]. In particular, the whole course goes through two phases: the development phase and the validation phase of the MathBasic Pro Android application. The development phase constitutes the creation and design of the Android app. In the validation phase, a pool of experts, which consisted of mathematics master teachers and information technology experts, validated the MathBasics Pro. Their suggestions were incorporated for the revisions of the app. As part of the validation phase, the revised version was pilot tested on end-users (students). Then, the endusers evaluated the Android application using the MEEGA (Model for the Evaluation of Educational Games) questionnaire. The rating and feedback from end-users provide relevant inputs for further refinement or endorsement of MathBasics Pro as an effective tool in developing mastery of integers and fractions.

Moreover, the study assessed the immediate development of students, but it did not investigate the app's long-term retention or the long-term effects on students' comprehension of mathematical concepts.

Statement of the Problem

This study aims to develop a numeracy android application named MathBasics Pro based on 5Is learning path for the enhancement of the performance of grade nine students on the operations of integers and fractions at Tampakan National High School during the school year 2024 – 2025. Specifically, it sought answers to the following questions:

1. What is the level of acceptability of the developed MathBasics Pro as evaluated by the experts in terms of appropriateness, appeal, content quality, instructional quality, and technical quality?

2. What is the level of acceptability of the developed MathBasics Pro as evaluated by the students in terms of usability and user experience?

3. What is the level of the students’ performance during the pretest and posttest?

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

4. What is the level of students' mastery in answering the drill practice in the MathBasics Pro in terms of fractions and integers?

5. Is there a significant difference in students' performance in the pre-test and posttest results?

6. Is there a significant relationship between the students' drill practice scores in the MathBasics Pro and students' performance in the posttest?

Theoretical and Conceptual Framework

The researcher supported the current study through the lenses of behaviorism theory and the concept of gamification.

Drill and practice are rooted in the theory of behaviorism. It focuses on the repetition of stimulus–response practice that leads to strengthening of habits and consequently facilitates mastery of content learning. The systematic repetition of concepts, examples, and practice problems distinguishes drill and practice as a teaching method. Drill and practice, a disciplined and repetitive exercise, serves to teach and perfect a skill or procedure [23]. To become proficient or learn something, this method of teaching makes it easier to get that knowledge or skill through organized training that includes doing something repeatedly, practicing, and taking part in a rehearsal. Drill and practice are like memorization in that they involve repetition of specific skills, such as multiplication or writing. Drill and practice should lay the groundwork for more meaningful learning, enhancing or preserving one's specific skills.

A behaviorist technique known as drill and practice involves repeatedly presenting the same materials to students until they achieve mastery. Repetition or repetitive exercises are a simple technique that educators can employ to enhance their students' mathematical abilities. Students can more quickly understand concepts by repeating and reviewing previous concepts, teachings, and information [7]. During every round, students are presented with similar questions or tasks to complete, and a specific percentage of correct responses or actions advances the student to the subsequent level of difficulty [13]. The researcher incorporates this concept into the development of MathBasics Pro. There will be 5 categories for the topics about fractions namely: Fractions-Impress, Fractions-Identify, Fractions-Inspire, Fractions-Inspect and Fractions-Invoke which follows the integration of the 5Is learning path [8]. Additionally, there are also five categories for the topics about integers namely: Integers-Impress, Integers-Identify, Integers-Inspire, Integers-Inspect and Integers-Invoke. Each category will have 3 levels that will have an increasing difficulty. Before progressing to the subsequent level, students will respond to 15 similar questions on a specific algebra prerequisite topic on each level.

In the context of education and mathematics, behaviorist teaching methods typically involve the teacher presenting students with an "appropriate" response, which they would repeat until they mastered the task [32]. Hence, giving the students the opportunity to have constant practice could increase mastery of concepts.

Moreover, the review of the basic math concepts will help students in dealing with more complex topics with ease. Students are more adept at understanding concepts at a quicker pace by reviewing and repeating prior lessons, formulas, and information [7]. By answering questions on algebra prerequisites through the Android application, students can recall and review those forgotten concepts, which hinders them in grasping the higher math topics.

In mathematics education, technology is employed and incorporated in various aspects, such as the delivery of content and the evaluation [14]. The students' interest was captivated using digital devices for practicing and drilling mathematics, as it allows them to connect the course material to real-world scenarios [15].

The concept of "gamification," which has gained popularity since 2010, is evident in the fields of health, education, and business [12]. Gamification has emerged as an engaging approach to enhance experiences and encourage participation in diverse contexts [37]. Most students do not find traditional classroom activities enjoyable Therefore, the use of game-like mobile applications such as MathBasics Pro may capture students' attention and aid in their mastery of math topics through consistent practice.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Research indicates that gamification can have a beneficial impact on the educational process [19], [20]. Furthermore, one remarkable aspect of gamification's application in the field of education is its adaptation to learners. Consequently, learners with varying levels of proficiency will find it simpler to engage in the learning environment in a meaningful manner [30]. Regardless of their current mastery level on fractions and integers, students will find it attractive when the drill and practice are incorporated in the form of a game. This study established its objective based on the belief that gamification could enhance the mastery of algebra prerequisites among ninth graders.

Based on the above theories, the researcher will use the one-group pretest-posttest quasi-experimental design to build the Android app. The study aims to develop a mobile application that will provide students an opportunity to drill and practice on algebra prerequisites with the help of their mobile phones.

Figure 1 illustrates the conceptual paradigm of the study, which reflects the development of MathBasics Pro.

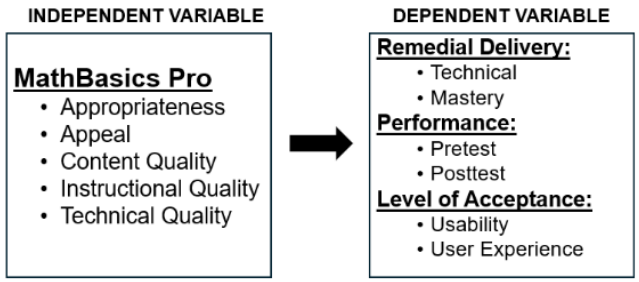

Fig. 1 The Conceptual Paradigm of the Study

In particular, the independent variable of the study is the MathBasics Pro, which will be evaluated by the experts in terms of its appropriateness, appeal, content quality, instructional quality, and technical quality. These qualities will be one of the considerations of the researcher in the overall development of the Android application.

The dependent variables of the study are remedial delivery, performance level, and level of acceptance among the students. Students' performance will be compared prior to and after the use of the MathBasics Pro through the pretest and posttest. Students' overall acceptance of the application will be evaluated in terms of its usability and user performance.

METHODOLOGY

Research Design

This research employed a quasi-experimental design with one group pretest-posttest methodology. The quasi-experiment is the manipulation of the independent variable without randomization [21]. In this study, it was utilized to test the effect of constant practice using an android application named MathBasicS Pro in mastering algebra pre-requisites particularly, fractions and integers. A pretest was given to the participants of the study. Reference [29] enumerated the misconceptions on the algebraic prerequisites concept that occur in students which is the basis in making the assessment tool. Then, the mobile application was utilized by the students to practice operations involving fractions and integers incorporating the 5Is learning path [8]. After answering all the categories and levels in the mobile app, a posttest was given to the students to evaluate the outcomes. The performance comparison is derived from the scores of the pretest and posttest following the utilization of the mobile application.

Locale of the Study

The research was conducted at Tampakan National High School (TNHS), situated in Poblacion, Tampakan, South Cotabato. It is a public secondary school catering junior and senior high school students, with a total population of 2,210 students and 86 teaching staff along with 11 non-teaching staff. The school was recognized

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

as a Regional SBM Level 3 practitioner, reflecting its commitment to provide quality education among its students.

Respondents of the Study

The ninth-grade students of Tampakan National High School enrolled in the academic year 2024-2025 under the K to 12 Curriculum are the participants of the study. A total of seventy-eight (78) students in Grade 9 Virgo, and Grade 9 Ursa used the MathBasics Pro in their National Mathematics Program (NMP) class. The NMP will occur four times weekly, with each session lasting 30 minutes [11]. Currently, there is no established method for conducting the said program. This is one of the reasons of the researcher in developing the android application to improve the algebra prerequisite skills of the students utilizing the NMP time. The NMP is one of the four main parts of the MATATAG plan to improve math and numeracy across all grade levels. This goal is part of the comprehensive DepEd initiative to recover learning losses, the National Learning Recovery Program (NLRP).

The student-participants answered the pre-test and post-test questions on integers and fractions. After a period of using the mobile application, they answered a questionnaire adopted from MEEGA+ measurement instrument that evaluates the level acceptability of MathBasics Pro [30].

Additional research participants were the set of experts who will validate the mobile android application. The group of experts is composed of three mathematics master teachers, one school head (a master's graduate in mathematics) and two IT experts who were master teachers and the ICT coordinators in their respective schools. The six experts will critic MathBasics Pro in terms of appropriateness, appeal, content quality, instructional quality, technical quality to test the level of acceptance of the android application.

Sampling Technique

The researcher employed purposive sampling in identifying a total of seventy-eight students from Grade 9 Virgo (38 students) and Grade 9 Ursa (40 students). These students were currently enrolled at Tampakan National High School during the academic year 2024-2025. The names will be taken from the School Form 1 downloaded from DepEd's Learner Information System (LIS) platform.

Data Gathering Instruments

The following instruments were used in this study:

First is the questionnaire to test the level acceptability of the Developed MathBasics among Experts. In the evaluation of the MathBasics Pro, the evaluators indicated the extent of their agreement or disagreement to the statements under the criteria terms of appropriateness, appeal, content quality, instructional quality, and technical quality [3]. The evaluation form is comprised of 26 statements with range given as labelled 4- Strongly Agree, 3- Agree, 2- Disagree, and 1-Strongly Disagree.

Second is the questionnaire to test the Level of Acceptability of the Developed MathBasics Pro among students. The grade 9 students of Tampakan NHS indicated the extent of their agreement or disagreement to the statement under the criteria of usability and user experience. The evaluation form is comprised of 35 statements with range given as labelled 4- Strongly Agree, 3- Agree, 2- Disagree, and 1-Strongly Disagree. The questionnaire is adopted from MEEGA+ measurement instrument [30].

Third is the test used in the pretest and posttest. To determine the mathematics level of performance of the students before and after the usage of MathBasics Pro, the researcher constructed a 50-item test on integers and fractions. The topics to be included in the test came from the misconceptions on the algebraic prerequisites concept that occur in students [29]. It was administered in the form of pre-test and post-test. A Table of Specification (TOS) was made to ensure the proper distribution of the test items.

Before the pilot testing, the test was rated by three mathematics experts in terms of appropriateness, content and form and structure using a questionnaire.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

The pilot testing was administered among 36 grade 10 students. The researcher identified the 27% lower group and 27% upper group of the total students who participated in the pilot testing. The test items' index of discrimination and difficulty were interpreted in accordance with the guidelines [23].

The reliability coefficient assessed the internal consistency, homogeneity, and response dependability of the study instrument. It also served as the basis for accepting the test tool.

The research instrument's computed reliability coefficient is 0.91, which means that the test is excellent for exam. The research instrument was both valid and reliable, as evidenced by the results of the validation from the experts and reliability evaluations.

Data Gathering Procedure

This study adhered to the standard operating procedure in conducting research. Upon obtaining approval from the Dean of the Graduate School, the researcher undertook the following steps:

A formal permission letter was submitted to the Schools Division Superintendent (SDS) of the Division of South Cotabato, specifically seeking approval to conduct the study at Tampakan National High School and utilized the researcher's official time, her National Mathematics Program (NMP) period for data gathering. The same letter was presented to the school principal of TNHS, asking permission to conduct the study, conduct a pilot testing among grade 10 students, administer a pretest and posttest exam among the participants of the study and to use the MathBasics Pro in the 30-minute NMP time and the extra 15 minutes of time period (the school followed the mandate to have a 45-minute time period). Please see appendix M for the schedule of the mobile app administration among the participants.

The researcher and the developer of the mobile application commenced the development of the mobile application after obtaining permission from the SDS and the school principal. To ensure the mobile application's quality, a panel of experts navigated and validated the MathBasics Pro using the questionnaire. Their feedback and suggestions were carefully incorporated to enhance the quality of the mobile application.

The validity of the test questions was ensured through pilot test administered to 36 grade 10 students of Tampakan NHS. The pilot test facilitated rigorous item analysis to calculate the discrimination and difficulty indexes. The Cronbach Alpha Formula was employed to conduct a reliability test. Following validation, the pretest was administered to the student-participants to assess the initial proficiency level of the students.

Next, the application was installed by the student-participants in their mobile phones. After finishing all the levels in the MathBasics Pro, they evaluated the app using the MEGGA+ questionnaire.

To assess the final proficiency levels, a posttest was administered. The raw scores from the pretest and posttest were transmuted using transmutation table of the initial grade from the Dep. Ed. Oder No.8, s.2015 and they were tabulated for interpretation. To determine if there is a significant difference in the pre-test and post-test, z-test was used.

The scores of the students from each level and categories in the MathBasics Pro were recorded. Mean and standard deviation of those scores were computed. To assess the relationship of the students' performance in the Posttest and the MathBasics Pro, Pearson-r correlation was utilized.

Statistical Treatment of Data

In this study, the statistical treatment of data employed the weighted mean to analyze results of the evaluation for the MathBasics Pro which will be undertaken with the help of experts in the field of Mathematics and Information Technology. The experts will evaluate the mobile app using Likert's Rating Scale, scoring between 1 to 5, 1 being the lowest score and 5 being the highest.

Weighted means will also be used to analyze the data from the Likert scale on the level of acceptability of the MathBasics Pro among students. The interpretation above was also used to have the verbal interpretation of the weighted mean gathered from the students.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

The raw scores from the pre-test and post-test were transmuted according to the transmutation table of the initial grade from the Dep. Ed. Oder No.8, s.2015. To determine the level of the grade nine (9) students' performance in on integers and fractions, the researcher used the grade scale interpretation from the same DepEd Order.

The mean of the transmuted scores were solved and it was treated using the z-test to test if there is a significant difference between the pretest and posttest scores.The mean and standard deviation of the scores of the students in each level and category were also calculated and transmuted in accordance with the transmutation table from the Dep.Ed. Oder No.8, s.2015. Additionally, a verbal interpretation was used.

Pearson r correlation was used to determine the relationship between the performance of students in the Posttest and their scores in the MathBasics Pro.

RESULTS AND DISCUSSION

Level of Acceptability of the MathBasics Pro among the Experts

Table 1. Summary of the Grand Mean Ratings on the Appropriateness, Appeal, Content Quality, Instructional Quality and Technical Quality of the MathBasics Pro among the Experts

Indicators	Mean	SD	Interpretation
Appropriateness	5.00	0.00	Excellent
Appeal	4.83	0.18	Excellent
Content Quality	5.00	0.00	Excellent
Instructional Quality	4.93	0.23	Excellent
Technical Quality	4.73	0.06	Excellent
Grand Mean	4.90	0.11	Excellent

The panel of experts generally evaluated the MathBasics Pro as an excellent supplemental material in strengthening the students' foundation in mathematics as evidenced by the mean of 5.00 in terms of appropriateness as shown in Table 1. It implies that the MathBasics Pro is meticulously developed to meet student learning goals. Three levels of increasing difficulty are present in each category. Students learn core concepts before moving on to more complicated ones. Students' reading levels were matched with simple words and phrases. As the user navigates the smartphone app, increasingly sophisticated terminology and ideas are introduced, improving reading comprehension and math abilities.

Educational apps must be suited to maximize efficacy and learning results. Educational applications that provide users the correct amount of flexibility and challenge might inspire and interest them to study more [6]. Research shows that curriculum-based apps may deliver high-quality education globally, improving reading, mathematics, science, problem-solving, and self-efficacy. Choose teaching-friendly and student-centered educational applications to improve learning [16].

The MathBasics Pro is appealing to its intended users as shown by a mean of 5.0 as rated by the experts in terms of its appeal. It indicates that the mobile app effectively captivates the interest of students by utilizing interactive, engaging features that simulate a game-like experience on the users' mobile devices. The mobile application developer employs various techniques, including interactive elements, animations, and colorful graphics, to establish a dynamic and visually appealing environment. Not only that, but the app uses real-life examples and relatable scenarios to show how the ideas can be used in real life, which makes the learning experience more relevant and important. Moreover, the application seamlessly blends aesthetic appeal with practicality.

Research shows that educational applications that integrate interactive features, including multimedia content and gamification, can enhance student motivation and knowledge retention by converting conventional lessons

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

into engaging learning activities [16]. Furthermore, the portability and convenience of mobile devices allow learners to access educational content at any time and in any location, which further enhances the appeal of these applications [25]. To this end, it is imperative to create educational Android applications that are both accessible and engaging to promote positive educational outcomes.

The mean of 5.0 in terms of content quality as shown in Table 1 indicates that the panel of experts deemed the MathBasics Pro's content as excellent. The content of the Android Application is in accordance with the algebra prerequisite skills that students need to acquire. It also offers the potential to cultivate advanced cognitive abilities, including inquiry and critical reasoning. Moreover, it is free of ideological, cultural, religious, ethnic, and gender biases and prejudices. The application has the capacity to attract the interest of its intended users.

The integrity of content in educational applications is essential for the development of effective learning experiences and outcomes. Structured information and resources are provided by high-quality content, which facilitates the acquisition and comprehension of new knowledge and skills [28]. This enhances learning. Additionally, it facilitates accessibility, enabling learners to interact with materials in a manner that is both convenient and inclusive. Additionally, the reliability and efficacy of content that is consistent with educational standards are guaranteed, thereby promoting positive learning experiences [5]. Consequently, it is imperative to prioritize the creation of high-quality content in educational applications to facilitate successful educational outcomes and accommodate a wide range of learning requirements.

The MathBasics Pro was generally rated excellent by the experts in terms of its instructional quality, as evidenced by the mean of 4.93 as presented in Table 1. Further, it can be claimed that the Android application is of high educational value, which is a beneficial supplement to the curriculum and can be used during the National Mathematics Program (NMP) session, which is one of the DepEd's initiatives to cope with learning gaps caused by the pandemic. The app facilitates interactive learning, which enables the user to interact with it by giving their answers to the questions at each level. The app uses graphics and colors for appropriate instructional purposes. Thus, the app achieves its defined purpose.

The instructional quality of educational Android applications is essential for improving learning outcomes by promoting engagement, motivation, and the acquisition of knowledge effectively. Features like gamification, personalized learning paths, and interactive content have been shown to keep students interested and motivated in these apps, leading to high-quality instructional design [35]. In addition, research suggests that applications with instructional content that is well-organized can enhance learning outcomes and have a positive impact on classroom dynamics.

The MathBasics Pro was generally rated excellent by the experts in terms of its technical quality, as evidenced by the mean of 4.73. It suggests that the Android application satisfies the quality standard. The software operates quickly and requires very little waiting time. Users of the app can utilize it in an easy and independent manner. Visual presentations (non-text) are clear and easy to comprehend which sustain the user's interest without diverting their attention. There have been no technical difficulties with the application.

The MathBasics Pro got an overall excellent rating of 4.90 which means the application meets the quality of standard. The grand mean ratings for the android application were highly favorable, indicating its suitability for the grade 9 students.

Level of Acceptability of the MathBasics Pro among the Students

Table 2 Level of Acceptability of the MathBasics Pro among the Students in terms of its Usability

Indicators	Mean	SD	Verbal Description
Aesthetics	3.91	0.73	Very Satisfactory
Learnability	3.57	1.00	Very Satisfactory

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Operability	3.77	0.96	Very Satisfactory
Accessibility	3.67	0.96	Very Satisfactory
Section Mean	3.73	1.00	Very Satisfactory

Table 2 shows the rating of the students per dimension under the Usability quality factor. The Usability quality factor is composed of four dimensions, namely, aesthetics, learnability, operability, and accessibility, which got the following ratings: 3.91, 2.57, 3.77, and 3.67, respectively. All the dimensions got a very satisfactory rating. The MathBasics Pro has an overall rating of 3.73 for the Usability quality factor, which is highly satisfactory. This rating indicates that the application is user-friendly.

Usability is the extent to which the MathBasics Pro can be utilized by specific users, particularly students, to improve their performance in algebra prerequisites with effectiveness and efficiency in a specific context of use [30]. Aesthetic dimension focus is if the applications' interface facilitates user interaction that is both enjoyable and exciting. Learnability is the ability of the application to be utilized by specific users to achieve specific learning objectives, such as the acquisition of the ability to operate the game with efficacy, efficiency, freedom from risk, and satisfaction in a specific context. Operability means the extent to which a game possesses attributes that facilitate its operation. The accessibility dimension refers to the user-friendliness of the fonts and colors used in MathBasics Pro.

Table 3 Level of Acceptability of the MathBasics Pro among the Students in terms of its User Experience

Indicators	Mean	SD	Interpretation
User Error Protection	3.56	0.97	Very Satisfactory
Confidence	3.76	0.86	Very Satisfactory
Challenge	3.69	0.98	Very Satisfactory
Satisfaction	4.01	0.84	Very Satisfactory
Social Interaction	1.00	0.00	Poor
Fun	3.72	0.87	Very Satisfactory
Focused Attention	3.46	0.92	Very Satisfactory
Relevance	3.83	0.86	Very Satisfactory
Perceived Learning	3.96	0.92	Very Satisfactory
Grand Mean	3.44	1.24	Very Satisfactory

Table 3 shows the rating of the student in the dimensions under the User Experience quality factor. The User Experience quality factor encompasses nine distinct dimensions. The user error protection, confidence, challenge, and satisfaction got mean scores of 3.56, 3.76, 3.69, and 4.01, which are all very satisfactory. Among the nine dimensions, only the social interaction got a poor rating of 1.00. Moreover, the fun, focused attention, relevance, and perceived learning got mean scores of 3.72, 3.46, 3.83, and 3.96, respectively, which are all very satisfactory ratings. The user experience is a quality factor that encompasses the student's significant engagement with the task offered by the Android application, including their perspectives on learning, emotions, pleasures, and interactions with the game, environment, and other players [30].

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

The user error dimension means that the game safeguards users from making errors. The confidence dimension providing opportunities to the users to progress in the study of educational content by their effort in going through the different categories and levels in the Android application and demonstrating their abilities amidst the increasing difficulty. The challenge dimension was assessed to determine if the Android app is challenging enough for the learner's competency level, and if new obstacles and scenarios were introduced throughout the game to reduce fatigue and maintain students' interest. Additionally, students evaluated their contentment with the extent to which they believe their diligent efforts have yielded learning outcomes which falls under the satisfaction dimension. The focused attention dimension refers to the extent to which the application captures the attention, focused concentration, absorption and the temporal dissociation of the student-users. The fun dimension evaluated the students' feelings of delight, happiness, relaxation, and distraction. The students evaluated the application's relevance to its intended purpose of mastering fractions and integers, as well as their ability to connect the application's content to their professional or academic future. The perceived learning dimension refers to the application's effectiveness as a learning resource for mastering fractions and integers.

Table 4 Summary Level of Acceptability of the MathBasics Pro among the Students

Quality Factor	Mean	SD	Interpretation
Usability	3.73	0.94	Very Satisfactory
User Experience	3.44	1.24	Very Satisfactory
Grand Mean	3.59	1.17	Very Satisfactory

The overall acceptability level of the MathBasics Pro among students is shown on Table 4. The Android application got a mean rating of 3.37 with a standard deviation of 0.94 on the Usability quality factor and got a mean rating of 3.44 and a standard deviation of 1.25. Both quality factors got a very satisfactory rating that makes the overall acceptability rating of 3.59 which is considered very satisfactory.

Numerous studies have demonstrated the efficacy of educational mobile applications in enhancing learning outcomes, and they have been widely adopted and well-received by students [30]. Reference [4] conducted a study which indicates that the perceived usefulness and simplicity of use of mobile learning applications are closely correlated with the acceptance of students, which significantly contributes to their overall positive experience. Reference [34] also suggests that mobile applications are more likely to be adopted by students when they are designed with user-friendly interfaces and explicit educational objectives, thereby fostering a productive learning environment. These results illustrate that educational mobile applications can obtain a high level of acceptability among students when they satisfy critical user experience criteria.

Level of Students' Performance During the Pretest and Posttest

The researcher calculated the mean scores, converted them into percentage scores, and subsequently adjusted those scores according to the transmutation table [10], referred to as the Policy and Guidelines on Classroom Assessment for the K–12 Basic Education Program, to assess the academic achievement of the students in their pretest and posttest. The same DepEd order descriptors designated for the pretest and posttest were utilized to present the transmuted scores.

Table 5 Pretest and Post Mean Scores of the Students

Test	Mean	SD	Verbal Description
Pretest	69.46	3.30	Did Not Meet Expectations
Posttest	77.82	7.25	Fairly Satisfactory

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

The table 5 displays the students' mean scores from the pretest and posttest. The students achieved a mean score of 69.46 (70%) on the pretest, with a standard deviation of 3.30, and a mean score of 77.82 (78%) on the posttest, with a standard deviation of 7.25.

The pretest scores did not meet expectations, suggesting that students struggle with fractions and integers prior to utilizing MathBasics Pro. Despite the mean score in the posttest rising to a Fairly Satisfactory level, it remains low. Nevertheless, the slight improvement in the mean score indicates that the Android application positively influences the mastery of algebra prerequisites.

The positive impact of educational interventions is frequently illustrated by the comparison of pretest and posttest results, which often reveals substantial enhancements in students' academic performance. Recent research has demonstrated substantial improvements in posttest scores when contrasted with pretest scores, underscoring the advantageous effects of a variety of learning methodologies and instruments. For instance, there is a study that observed a significant increase in the posttest scores of students who utilized interactive mobile applications for learning [22]. This finding implies that the material was more easily understood and retained. In the same vein, another study noted that students' posttest results improved because of their participation in a blended learning environment [36]. This environment was characterized by the integration of online and in-person learning, which resulted in enhanced academic performance and comprehension. Additionally, another research showed a significant rise in post-test scores following a gamified learning approach [18]. This highlights the significance of active learning strategies in achieving deeper learning outcomes. All these results show that educational interventions improve student performance in a measurable way, as shown by the fact that post-test scores are higher than pretest scores.

Level Of Students' Mastery in Answering the Drill Practice in the Mathbasics Pro

The tables present the average scores of students for each category in the Android application.The MathBasics Pro anchored its category in the 5 Is Learning Path [8]. There are 10 categories, 5 of which pertain to the topic fractions: Fractions-Impress, Fractions-Identify, Fractions-Inspire, Fractions-Inspect, and Fractions-Invoke. The last five pertain to the subject of integers: Integers-Impress, Integers-Identify, Integers-Inspire, Integers-Inspect, and Integers-Invoke. Each category is composed of three levels with increasing difficulty, each of which contains fifteen questions. An explanation follows the revelation of the correct answer.

Table 6 Level of Students' Mastery in Answering the Mathbasics Pro (Fractions)

Category	Mean	Transmuted Score	SD	Interpretation
Fractions-Impress	11.00	83	2.95	Satisfactory
Fractions-Identify	10.25	80	3.02	Satisfactory
Fractions-Inspire	10.24	80	2.63	Satisfactory
Fractions-Inspect	10.77	82	2.68	Satisfactory
Fractions-Invoke	9.91	78	2.54	Fairly Satisfactory
Grand Mean	10.44	81	2.79	Satisfactory

Table 6 presents the average scores of the students in MathBasics Pro on the topic of fractions. The students achieved a mean score of 11.00 (83%) in the first category, Fractions-Impress, with a standard deviation of 2.95. This category encompasses foundational concepts related to fractions, such as improper fractions, mixed numbers, and fractions. The subsequent category, Fractions—Identify, focused on the addition of fractions. The students achieved a mean score of 10.25 (80%) and a standard deviation of 3.02. The students achieved a score of 10.24 (80%) with a standard deviation of 2.63 in the Fractions-Inspire category, which pertains to the subtraction of fractions. For Fractions-Inspect, the students achieved a mean score of 10.77 (82%) and a standard deviation of 2.68 on the topics of multiplying and dividing fractions. For the final category, which pertains to

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

fractional problem-solving, the student achieved a mean score of 9.91 (78) with a standard deviation of 2.54. The overall score of the categories under the fraction's topic is 10.44 (81%).

The first category, Fractions-Impress, has the highest scores among the students. This category pertains to fundamental concepts of fractions that are sort basic for the students. The final category, which pertains to problem-solving involving fractions, received the lowest score and standard deviation. This implies that most students have trouble in problem-solving.

Table 7 Level of Students' Mastery in Answering the Mathbasics Pro (Integers)

Category	Mean	Transmuted Score	SD	Interpretation
Integers-Impress	10.87	82	2.76	Satisfactory
Integers-Identify	11.20	84	2.30	Satisfactory
Integers -Inspire	10.62	82	2.56	Satisfactory
Integers -Inspect	11.50	85	2.56	Very Satisfactory
Integers -Invoke	10.13	79	2.33	Fairly Satisfactory
Grand Mean	10.86	82	2.55	Satisfactory

Table 7 presents the Level of Students' Mastery in Answering the Mathbasics Pro on the topics about integers. In the first category, Integers-Impress which is about illustration of integers, the students got a mean score of 10.87 (82%) with a standard deviation of 2.77. In the next category, Integers-Identify, the students got a mean score of 11.20 (84%) with a standard deviation of 2.32. This category is about adding integers. The Integers-Inspire category is about subtracting integers. In this category, the students got a mean score of 10.70 (82%) with a standard deviation of 2.53. In the Integers-Inspect category, which is about multiplying and dividing integers, the students got a mean score of 11.55 (85%) with a standard deviation of 2.59. In the last category, Integers-Invoke which is about problem solving integers, the students got a mean score of 10.14 (79%) with a standard deviation of 2.38.

The mean score for the fourth category, Integers—Inspect, was the highest. This implies that the students are proficient in the multiplication and division of integers, a skill that is easy to recall. The final category, which pertains to solving integer-based problems, achieved the lowest average.

Table 8 Summary of the Level of Students' Mastery in Answering the Mathbasics Pro

Topic	Mean	Transmuted Score	SD	Interpretation
Fractions	10.45	81	2.77	Satisfactory
Integers	10.89	82	2.32	Satisfactory
Grand Mean	10.67	82	2.68	Satisfactory

Table 8 shows the summary of level of students' mastery in answering the MathBasics Pro. In both topics, fractions and integers, the students got a satisfactory rating of 81% and 82 % respectively and in their overall rating is 82% which is also satisfactory.

In both topics, fractions and integers, the students have a little difficulty in answering problem solving. This is also evident in the actual classroom setting. The difficulties students encounter in problem-solving can often affect their academic performance. According to research, a significant number of students experience difficulties with critical thinking and lack effective problem-solving strategies. Reference [33] discovered that

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

students encounter challenges with open-ended problems because of inadequate cognitive tools. Anxiety and a lack of confidence worsen the complexity of problem-solving tasks. These challenges underscore the importance of targeted support to enhance students' problem-solving abilities. Hence, students must be exposed to more problems solving questions for them to have a constant practice and gradually gain the confidence in dealing with problems.

Significant Difference in Students' Performance in the Pre-Test and Posttest Results

The table 14 present the results of the z-test analysis that was conducted to compare the pretest and post results of the students before and after the usage of the MathBasics Pro.

Table 9 z-test analysis on the Pretest and Posttest Results Before and After using MathBasics Pro

Test	Mean	SD	Mean Difference	p-value
Pretest	69.46	3.30	8.36	0.00
Posttest	77.82	7.25		

$\alpha = 0.05\ level\ of\ significance$

The mean score in the pretest was 69.46 with a standard deviation of 3.30, and in the posttest, it was 77.82 with a standard deviation of 7.25, as shown in Table 19. This led to a computed p-value of less than the 0.05. Therefore, the null hypothesis is rejected, indicating a significant difference between the pretest and posttest results. This outcome indicates that the MathBasics Pro had the desired effect on students' performance.

The analysis results suggest that the Android application utilized during the study had a beneficial effect on learning outcomes, as evidenced by a substantial increase in the students' performance from the pretest to the posttest. Mobile-based educational tools are effective in enhancing student mastery and knowledge retention, as evidenced by the improvement in test scores. Recent research has illustrated the effectiveness of mobile applications in educational situations, particularly those that incorporate personalized learning paths and interactive features. For instance, there is a study that demonstrated that mobile applications substantially improved students' language learning performance by offering personalized lessons and real-time feedback [34]. Also, another study found that using educational apps for math led to better test scores because the apps could interest students through game-like features and adaptive learning methods [9]. These results support the current study, which demonstrated that the MathBasics Pro was significant in enhancing the academic performance of students.

Significant Relationship between the Students' Drill Practice Scores in the Mathbasics Pro and Students' Performance in the Posttest

Table 15 Pearson-r correlation Results between Students' Drill Practice Scores in the Mathbasics Pro and Students' Performance in the Posttest

	N	Mean	SD	r	p-value
Drill Practice Scores in the Mathbasics Pro	78	319.49	28.25	-0.01	0.93
Performance in the Posttest	78	77.82	7.25		

The table 15 present the correlation results between mastery of MathMasics Pro and the performance in Posttest. The Math Basics Pro students' mean score is 319.49, with a standard deviation of 28.25. The students' mean score on the posttest is 77.82, with a standard deviation of 7.25. The p-value is 0.93, and the computed r value is -0.01.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

This suggests a weak negative correlation between posttest performance and MathBasics Pro mastery since -0.01 is close to 0. There is almost no linear relationship, and if there is, it barely matters. The correlation is not statistically significant, as the p-value of 0.93 is significantly greater than 0.05. This suggests that the weak negative correlation observed is more likely due to random chance than a true relationship between the variables. The null hypothesis cannot be rejected, so we can say that there is no linear relationship between students' posttest performance and mastery in the MathBasics Pro.

This suggests that students may receive low scores when using MathBasics Pro, as it is merely a practice drill. Students may make mistakes, particularly in the first five questions, if they lack a sufficient understanding of the specific subtopic of fractions or integers. However, the display of the solution after each question may gradually boost their confidence to answer subsequent questions. One of the most effective pedagogical techniques is the use of practice tests to enhance learning, or test-enhanced learning [27]. The students' performance was improved when they were exposed to drill-and-practice, and drill-and-practice was advantageously utilized to enhance students' performance in mathematics.

CONCLUSIONS

The study's findings led to the following conclusions:

Experts rated the Android app as outstanding in appropriateness, allure, content quality, instructional quality, and technical quality. Positive feedback highlights the app's capacity to meet educational standards, engage users, and deliver high-quality content and learning. Technical excellence makes the software a great tool for mastering algebra prerequisites. These experts' ratings show that the Android app is well-designed and may provide meaningful learning experiences.

The students' responses indicates that they had a pleasant and engaging experience with the Android application's appealing design and functionality despite the Android application’s limitations such as the social interaction features and offline use.

Based on the students' scores while utilizing the Android application, it is evident that they experienced some difficulty in dealing with problem-solving tasks. The application was generally effective in facilitating learning of basic concepts like fractions and integers; however, the difficulties students faced in problem-solving indicate that certain areas may require further refinement.

The z-test analysis of the pretest and posttest results indicates that MathBasics Pro had a positive effect on students' performance, particularly in terms of their mastery of integers and fractions.

However, the scores of the students in the MathBasics Pro does not affect their scores in their posttest which implies that students may make errors during the practice drill with the MathBasics Pro, but they progressively develop the confidence to answer subsequent questions as the correct answer is revealed after each question.

RECOMMENDATIONS

Based on the conclusion of the conducted study, the researcher recommends the following:

1. The MathBasics Pro can be used as supplementary material in the National Mathematics Program (NMP) time to address the mathematics learning gaps.

2. The MathBasics Pro can be enhanced by incorporating social interaction features and other functions that are more appealing to student users. It may be customized for offline use.

3. Additional fundamental mathematical concepts may be integrated into the MathBasics Pro to improve students' core understanding of mathematics, in addition to integers and fractions.

4. To facilitate the mastery of mathematical concepts, the researcher suggests that students must be provided with regular opportunities for drill practice.

5. Enhancement of students' problem-solving skills must be an area for further studies.

6. Conducting the study in various institutions or regions with a more diverse and extensive student body would enhance the generalizability of the findings.

7. A further study may be conducted to evaluate the long-term retention of math concepts that were acquired through the MathBasics Pro. Incorporating interviews, focus groups, or open-ended survey queries could offer more nuanced insights into the app's impact on students, their preferences, and the obstacles they encountered.

REFERENCES

1. Abucejo, C. M. L., Amodia, J. B. S., Calorin, R., Deo, N. F. J., Fuentes, M. J. E., Lamila, K. N. E., Memoracion, J. M. E., Patiluna, K. M. M., Sabello, L. C., Vergara, G. R. B., Taneo, J. D., Cabello, C. A., & Minyamin, A. V. (2022). Going back to elementary years: the parents lived experiences in modular distance learning. Zenodo (CERN European Organization for Nuclear Research). https://doi.org/10.5281/zenodo.6791851
2. Agustin, J. M., & Abad, J. M. (2022). Challenges in studying mathematics using self-learning module during COVID-19 pandemic. American Journal of Educational Research, 10(4), 182-187.
3. Alegre, C. (2011). Development of Computer- Aided Instructional Tool in Linear Equation in Two Variables. Unpublished Dissertation. Notre Dame of Marbel University. Koronadal City.
4. Al-Rahmi, A. M., Al-Rahmi, W. M., Alturki, U., Aldraiweesh, A., Almutairy, S., & Al-Adwan, A. S. (2022). Acceptance of mobile technologies and M-learning by university students: An empirical investigation in higher education. Education and Information Technologies, 27(6), 7805–7826. https://doi.org/10.1007/s10639-022-10934-8
5. Alzahrani, L., & Seth, K. P. (2021). Factors influencing students' satisfaction with continuous use of learning management systems during the COVID-19 pandemic: An empirical study. Education and Information Technologies, 26(6), 6787–6805. https://doi.org/10.1007/s10639-021-10492-5
6. Amaefule, C. O., Breitwieser, J., Biedermann, D., Nobbe, L., Drachsler, H., & Brod, G. (2023). Fostering children's acceptance of educational apps: The importance of designing enjoyable learning activities. British Journal of Educational Technology, 54(5), 1351–1372. https://doi.org/10.1111/bjet.13314
7. Bates, A. (2020). Basic Math Teaching Strategies. Retrieved 03 April 2020 from https://resilienteducator.com/classroom-resources/basic-math-teaching-strategies/
8. Cajandig, A. J. S., & Lomibao, L. S. (2020). 5I's Learning Path with Cultural Approach Embedded to CAI on Student's Conceptual Understanding. American Journal of Educational Research, 8(10), 772–778. https://doi.org/10.12691/education-8-10-6
9. Chen, C., & Shou, J. L. a. W. (2018). How competition in a game-based science learning environment influences students' learning achievement, flow experience, and learning behavioral patterns. Educational Technology & Society, 21(2), 164–176. https://www.jstor.org/stable/26388392
10. DepEd Order No. 8 (2015). Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program.
11. DepEd Order No. 10 (2024). Policy Guidelines on the Implementation of the Matatag Curriculum.
12. Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification". In Proceedings of the 15th International Academic MindTrek Conference: Envisioning future media environments (pp. 9–15). Tampere, Finland: ACM. https://doi.org/10.1145/2181037.2181040
13. Drill and Practice | University of Illinois Springfield. (n.d.). Retrieved March 22, 2025, from https://www.uis.edu/ion/resources/oiai/drill-and-practice
14. Erduran, A., & Ince, B. (2018). Identifying mathematics teachers' difficulties in technology integration in terms of Technological Pedagogical Content Knowledge (TPCK). International Journal of Research in Education and Science, 555–576. https://doi.org/10.21890/ijres.428955
15. Hartman, R. J., Townsend, M. B., & Jackson, M. (2019). Educators' perceptions of technology integration into the classroom: a descriptive case study. Journal of Research in Innovative Teaching & Learning, 12(3), 236–249. https://doi.org/10.1108/jrit-03-2019-0044

16. Huntington, B., Goulding, J., & Pitchford, N. J. (2023). Pedagogical features of interactive apps for effective learning of foundational skills. British Journal of Educational Technology, 54(5), 1273–1291. https://doi.org/10.1111/bjet.13317
17. Johnson, J. D., & Williams, C. (2020). Mobile learning features preferred: An examination of students in the United Arab Emirates. International Electronic Journal of Mathematics Education, 15(3), em0596. https://doi.org/10.29333/iejme/8325
18. Kato-Lin, Y., Kumar, U. B., Prakash, B. S., Prakash, B., Varadan, V., Agnihotri, S., Subramanyam, N., Krishnatray, P., & Padman, R. (2020). Impact of pediatric mobile game play on healthy eating behavior: randomized controlled trial. JMIR Mhealth and Uhealth, 8(11), e15717. https://doi.org/10.2196/15717
19. Kim, J., & Castelli, D. M. (2021). Effects of Gamification on Behavioral Change in Education: A Meta-Analysis. International Journal of Environmental Research and Public Health, 18(7), 3550. https://doi.org/10.3390/ijerph18073550
20. Klock, A. C. T., Gasparini, I., Pimenta, M. S., & Hamari, J. (2020). Tailored gamification: A review of literature. International Journal of Human-Computer Studies, 144, 102495. https://doi.org/10.1016/j.ijhcs.2020.102495
21. Krishnan, P. (2018). A review of the non-equivalent control group post-test-only design. Nurse Researcher, 26(2), 37–40. https://doi.org/10.7748/nr.2018.e1582
22. Lee, J. J., & Hammer, J. (2011). Gamification in education: What, how, why bother? Academic Exchange Quarterly, 15(2), 146. https://www.uwstout.edu/soe/profdev/resources/upload/Lee-Hammer-AEQ-2011.pdf
23. Lim, C. S., Tang, K. N., & Kor, L. K. (2012). Drill and practice in learning (and beyond). In Springer eBooks (pp. 1040–1042). https://doi.org/10.1007/978-1-4419-1428-6_706
24. Madriaga, G. (2015). Teaching strategies and student's achievement in calculus. Master's Thesis. [Not Published]. Sultan Kudarat State University, ACCESS , EJC Montilla, Tacurong City , Sultan Kudarat
25. Martin, E. (2024, October 3). From classrooms to smartphones: The rise of mobile apps in education. eLearning Industry. https://elearningindustry.com/from-classrooms-to-smartphones-the-rise-of-mobile-apps-in-education
26. Nabayra, J. (2023). Mathematics Education amidst the pandemic: The experiences of Freshmen University students challenged at the margin. MIER Journal of Educational Studies Trends & Practices, 424–441. https://doi.org/10.52634/mier/2023/v13/i2/2519
27. Pan, S. C., & Sana, F. (2021). Pretesting versus posttesting: Comparing the pedagogical benefits of errorful generation and retrieval practice. Journal of Experimental Psychology Applied, 27(2), 237–257. https://doi.org/10.1037/xap0000345
28. Perez, M. (2025, January 10). Educational content: definition and why is it important. SMOWL Proctoring | Supervision system for online exams. https://smowl.net/en/blog/educational-content/
29. Permata, D., Wijayanti, P., & Masriyah, N. (2019). Students' misconceptions on the algebraic prerequisites concept: operation of integer numbers and fractions. Journal of Physics Conference Series, 1188, 012059. https://doi.org/10.1088/1742-6596/1188/1/012059
30. Petri, G., & Von Wangenheim, C. G. (2019). A method for the evaluation of the quality of games for computing education. Anais Dos Workshops Do VIII Congresso Brasileiro De Informática Na Educação (CBIE 2019), 951. https://doi.org/10.5753/cbie.wcbie.2019.951
31. Sezgin, S., Bozkurt, A., Yılmaz, E. A., & Van der Linden, N. (2018). Gamification, education and theoretical approaches: Motivation, engagement and sustainability in learning processes. Mehmet Akif Ersoy University Journal of Education Faculty, (45), 169-189. https://doi.org/10.21764/maeuefd.339909
32. Shan, Z. (2021). Behaviorism reinforcement learning and its application in mathematics teaching in primary and middle schools. Frontiers in Educational Research, 4(4). https://doi.org/10.25236/fer.2021.040419
33. Suhirman, S., & Prayogi, S. (2023). Overcoming Challenges in STEM Education: A Literature review that leads to Effective Pedagogy in STEM learning. Jurnal Penelitian Pendidikan IPA, 9(8), 432–443. https://doi.org/10.29303/jppipa.v9i8.4715
34. Sung, Y., Chang, K., & Liu, T. (2015). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. Computers & Education, 94, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

35. Wang, A. I., & Tahir, R. (2020). The effect of using Kahoot! for learning – A literature review. Computers & Education, 149, 103818. https://doi.org/10.1016/j.compedu.2020.103818
36. Wang, M., Binning, K. R., Del Toro, J., Qin, X., & Zepeda, C. D. (2021). Skill, thrill, and Will: The role of Metacognition, Interest, and Self-Control in Predicting student engagement in Mathematics Learning over time. Child Development, 92(4), 1369–1387. https://doi.org/10.1111/cdev.13531
37. Zare, S. K., Varnaseri, A., & Bayati, N. (2024). Identifying the applications of gamification for audience attraction in public libraries. Libri, 74(2), 171–184. https://doi.org/10.1515/libri-2023-0123