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Evaluation Of Computer Game On Quadratic Equations For Senior School Students

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Abstract: *Several research studies have linked students' poor performance in linear and quadratic equations to a need for instructional material to reinforce the students during mathematics class. Thus, adopting the Analysis, Design, Development, Implementation, and Evaluation Stages of the ADDIE model, this study developed and evaluated a computer game instructional package as a reinforcer for teaching linear and quadratic equations to senior school students in Nigeria. The study was of the descriptive design of ex-post facto. Ten computer programmers, twenty mathematics teachers, and sixty seniors in secondary school made up the study's sample. Data was gathered using the Evaluation Comments Questionnaire for Computer Programmers, Mathematics Teachers, and Students' Mathematics Achievement Tests. The comments received from the evaluation carried out by computer programmers showed that the computer game on linear and quadratic equations instructional Package was well designed and developed. Out of 70 responses items, 36 (51.4%) adjudged the Package as excellent, while 25 (35.7%) described that it was excellent, and 9 (12.9%) indicated that it was good. The students' Achievement Test results indicated that students' performance improved tremendously due to their constant practice with the game. Teachers of Mathematics should embrace and accept computer games as a complement to their verbal presentation.*

Keywords: **Evaluation, Computer Game, Linear and Quadratic Equations**

Introduction

Mathematics is central to Nigeria's Educational system due to its importance to nation-building (Ainur et al., 2023), which prompted the Federal Government of Nigeria to mandate that mathematics be taught in primary and secondary schools in the country (FRN, 2023). Mathematics is one of the significant entry requirements into the University. Admission to any tertiary institution requires a credit pass in Mathematics. Ineffective mathematics instruction at all levels of the Nigerian educational system is the root cause of the difficulty students face in understanding how to study the subject; poor teaching methods are one of the significant factors contributing to students' poor Mathematics performance (Permainan et al., 2021). According to Wang et al. (2023), lessons in mathematics are primarily lecture-based in Nigerian classrooms. To address the needs of the students, teachers, textbooks, chalkboards, and other facilities must be improved. Teachers have been trying to improve mathematics teaching through instructional materials such as computer games. The purpose of instructional materials in mathematics education is to support teachers' oral fact-presenting during a lesson which serves as concrete support to enhance better acquisition of the knowledge imparted by the teacher (Aduwa, 2021; Dlamini & Rafiki, 2022; Manzano Pérez et al., 2023). The need to use appropriate instructional technology to meet the learning demands of students in mathematics cannot be overemphasized. Chiu (2022) observed that students find it easier to solve problems and complete practice exercises when Information and Communication Technology (ICT) tools are used in the teaching and learning of mathematics.

However, students of the 21st century could be considered information-age citizens (Deng et al., 2020; Billman et al., 2018; Pellas, 2023). These students have acquired the ability to manage, evaluate, assess, cross-reference, and convert information into applicable personal knowledge. This was just as vital as learning how to obtain information. For several decades, researchers have demonstrated that, with a few notable exceptions, mathematics instruction has been characterized by the lecture method, an abstract formulation that only a small percentage of students seem to understand even though teacher-centered approaches to teaching mathematics still predominate in math classrooms. (Smale-Jacobse et al., 2019; Dunnigan & Halcrow, 2021; Karamert & Kuyumcu, 2021). Most students believe that teaching mathematics is uninteresting due to antiquated techniques and a shortage of teaching resources that can serve as lesson motivators. Learning technology integration has been used in many attempts to enhance mathematics education. The use of computer games to improve math instruction in the classroom is one exciting strategy that has been investigated (Dimosthenous et al., 2021; Al-Khateeb, 2019; Korkmaz et al., 2023; Singh et al., 2021).

Noah (2019) found that computers can raise students' achievement in Mathematics, depending on how they are used. Software packages for computer instruction have become popular due to the use of computers in the classroom. Given the

position of mathematics, educators must employ cutting-edge pedagogical techniques to help students meet the challenges of the subject, particularly in the information age. Using educational games to improve students' attitudes toward learning mathematics is a successful strategy. Educational games have been found to draw in and pique students' interest and boost their motivation and engagement in mathematics (Ro, 2021; Haleva et al., 2021; Parrella et al., 2022). There is compelling evidence that educational games with the right design can improve kids' math learning (Chiu, 2022; Dimosthenous et al., 2021; Esperanza et al., 2023; Williamson Shaffer et al., 2005). One of the ways the learning of mathematics can be encouraged, especially at the Secondary School level, is by improving instructional materials to supplement the factual information presented by the teacher. The improvised materials could be presented as games that learners can engage in for a better understanding of the concept (Dimosthenous et al., 2021). The mathematics teacher's knowledge, attitude, and experiences play a significant role in the effectiveness of educational games in the classroom. Therefore, professional development programs that focus on using educational games for mathematics instruction in the school are necessary to improve the quality of teachers. When players can perceive and affect the game's outcome based on mathematical considerations, a game is considered mathematical (Nance, 2020; Dimosthenous et al., 2021). Chiu (2022) noted that the teacher's place could not be replaced with the computer; instead, the teacher should be encouraged to use computer games and other innovative strategies to teach and learn mathematics better to attain the Millennium development goals.

The method of teaching mathematics in Schools has been identified as a critical factor contributing to the students' lack of interest in mathematics, which may be to blame for the student's subpar performance in the course. Yang et al. (2023) revealed that students exposed to the Computer Instructional Package as an instructional tool were motivated and showed greater interest in mathematics. The researcher further noted that apart from being motivated, students' achievement in the subject also improved tremendously as a result of students' continuous use and practice of mathematics problems using computer systems. It is observed that computer games promote numerous cognitive benefits in learners, such as motivation for learning, problem-solving, and critical thinking abilities that all students are expected to acquire from school, especially in mathematics. Liang et al. (2020) also carried out a study on using games to teach plane shapes at the primary school level. The results showed that games let kids have fun and relax during class while actively engaging them in learning.

Several researchers have affirmed that the appropriate use of computer games instructional packages for mathematics instruction could facilitate teaching and motivate students to learn mathematics (Dimosthenous et al., 2021; Williamson Shaffer et al., 2005). Adopting this Package into Education (Mathematics class) would be founded on the idea that this new technological tool has the power to completely transform the antiquated educational system and better equip students to tackle math challenges. This study developed and evaluated a computer game on linear and quadratic equations as a reinforcer for Senior School Students in learning linear and quadratic equations.

Desıgn and Implementatıon of Lınear and Quadratic Design

The production of the computer game was based on the Analysis, Design, Development, Implementation, and Evaluation stages (ADDIE) model. It was adopted by Chiu, (2022) in designing and developing the Package for two concepts in the mathematics curriculum of Kwara State, Nigeria's senior secondary school.

The researcher examines senior school students' learning needs using quadratic equations, assessing their prior knowledge, identifying challenges, and creating explicit objectives to guide the design process.

The researcher creates a computer game by establishing its structure, including interactive aspects, and connecting content with learning objectives to produce a dynamic and interesting learning experience.

The development step entails producing a computer game based on design standards, such as multimedia elements, interactive features, and platform compatibility, to ensure its practical actuality and effective implementation.

The researcher successfully implemented a computer game in senior school, incorporating it into the quadratic equations curriculum, resulting in a seamless integration and enjoyable teaching experience.

The evaluation step, the researcher involves assessing the computer game's impact on senior high school students' grasp of quadratic equations. This phase employs pre- and post-game assessments, questionnaires, and observations to assess effectiveness and inform future modifications, ultimately improving the learning experience in a technologically enhanced setting.

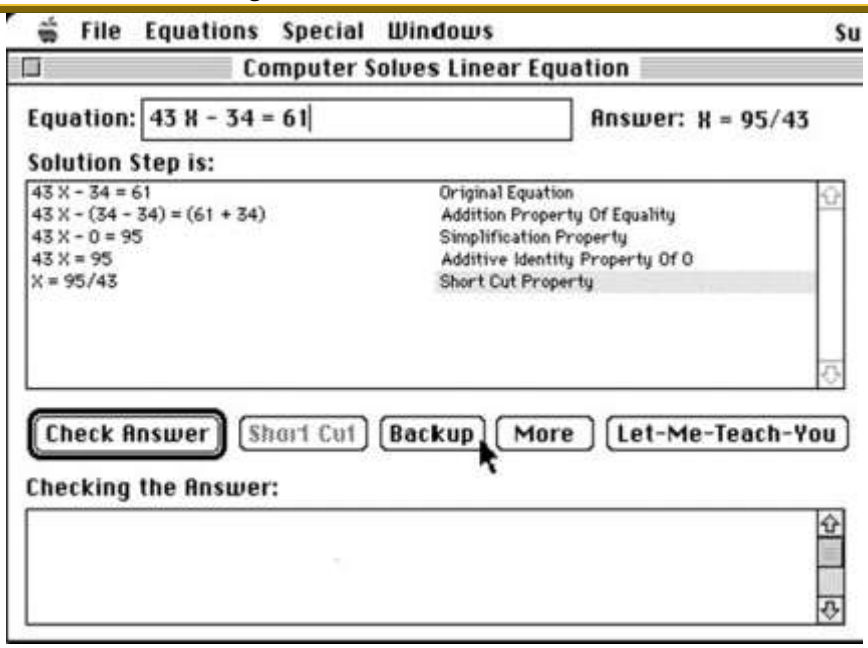

Figure 1. Solving Problem mode

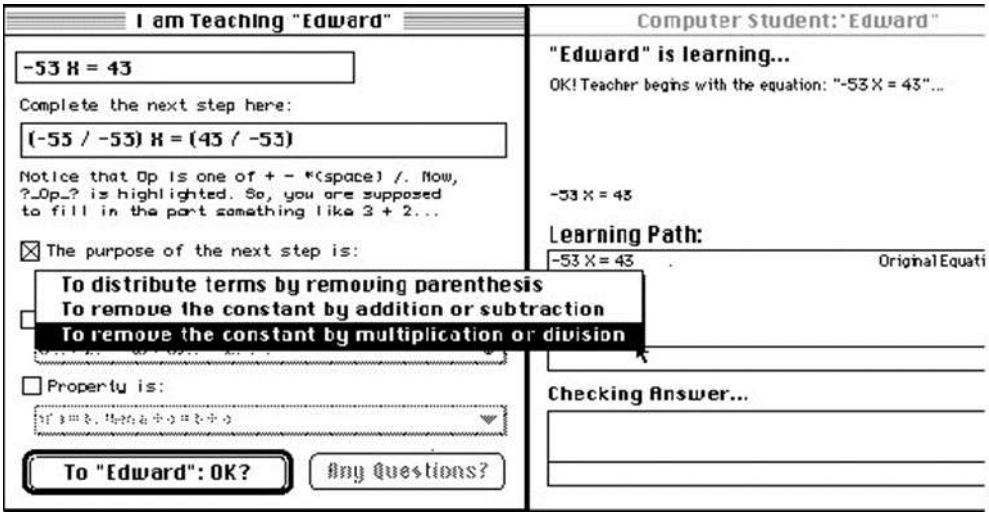

Figure 2. Tutoring mode

The three learning modes that comprise the entire environment are Tutoring, Guessing answers, and Solving Problems. Both the Guess Answer Mode and the Solving Problem Mode function as tutorials to assist beginners or intermediate students gain a comprehensive understanding of how to solve linear equations. In the Solving Problem Mode (see Figure 1), the student observes how a computer expert solves tasks. Students can switch between the tutoring and guess-answer modes when they gain number sense while solving problems. Students try to apply what they have learned in the Solving Problem Mode to tutor the computer to gain additional knowledge (see Figure 2). The learning agent requires the student to explain the problem-solving process regularly. The computer coach intervenes to guide the student when he gets stuck or misdescribes the process.

This study aimed to develop a computer game on linear and quadratic equations for senior secondary mathematics. Also, to evaluate the developed computer game on linear and quadratic equations in Senior Secondary by mathematics teachers and exposed students to a developed computer game on linear and quadratic equations in school mathematics class.

The study raised the following research questions:

• What are the computer programmers' comments on the developed computer game on linear and quadratic equations using the ADDIE model?

• What are the mathematics teachers' comments on using the developed computer game on linear and quadratic equations in teaching?

• How does the developed computer game affect students' mathematics achievement on linear and quadratic equations?

Methods

Research Design

This descriptive survey design using ex-post facto method to achieve the purpose of the study. This is a type of design that seeks to establish investigation among variables by observation, which researcher usually has no control over the variables of interest and therefore cannot manipulate them. Usually, data are collected after the event or phenomenon under investigation has taken place. The variables were being observed as have been treated in their natural occurrence.

Students' achievement levels were ascertained through pre-testing in the experimental and control groups, and the change in the learning outcome was measured through a post-test administered following the intervention. The dependent variable in this study was the students' achievement, and the independent variable was the computer game instructional strategy. The researcher was interested in analyzing and adjusting the independent variable (computer game) to see how it affected the dependent variable (mathematical achievement) using a pre-and post-test.

Sample

Ten computer programmers, 20 mathematics teachers, and 60 senior secondary school students in their fifth grade in Ilorin, Kwara State, Nigeria, made up the study's sample selected purposively from a population of 786 students. The fifth grade is the foundation class for senior secondary school classes. The two schools selected for this study had (1) at least one teacher with a BSc (Ed.) Mathematics qualification, (2) the teachers taught mathematics, (3) and the distance between the schools was considerable. A coin toss was used in each selected school to assign intact classes to groups randomly. Also, the selected schools and the teachers that participated in the evaluation of the Package based on the availability of computer systems and literate teachers in computers in the school selected.

Quality Measures

The face and content validity of the research instruments were evaluated critically by three experts on the researcher's designed Questionnaire Forms on Mathematics Teachers' Evaluation Comments (QFMTEC), Computer Programmers' Evaluation Comments (CPEC), and Students' Mathematics Achievement Test (SMAT). The subject matter content in the Package contained multiple-choice questions on linear and quadratic equations. The outcome of the appraisal of the items based on the experts' judgment gave a 0.85 index of logical validity. The validated instruments was trial tested to determine the reliability of the instruments using ten mathematics teachers, 24 students who were part of the study's target population but did not form part of the study. Also, the split-half reliability method establishes the instrument's internal consistency with a reliability coefficient of 0.84 and 0.92 respectively. The instrument was considered adequate using psychometric item analysis, with an average of 0.56 as the difficulty index, 0.63 for the discrimination average index, and -0.13 as the distracter average index for the items. The researcher implemented the following protocols to control for unrelated variables that could introduce bias into the study. The researcher put together a standardized training program for the teachers who worked as research assistants to control the variables related to the teachers such as the use computer games in teaching mathematics. The same research assistants conducted experimental and control groups. The test instruments were under the researcher's care, and research assistants helped only when asked by the teachers and when needed. The researcher assumed a supervisory role in averting the teachers' departures from the prescribed content of the lesson plans.

Data Collection

Before the study, two research assistants received training on the administrative processes of the research questionnaire from each participant that participated in the study. The researcher explained the rules of computer game to the two research assistants and provided an outline of the linear and quadratic equation expressions to be taught to learners. The research assistants taught the students on linear and quadratic equation expressions over three weeks before the commencement of the experiment.

There were two phases to the study: the initial stage and the execution stage. The experimental and control groups underwent pre-testing during the initial stage. Students' Mathematics Achievement Test (SMAT) before the teaching. The researcher created the 20 items that made up the SMAT. Some examples of linear and quadratic expressions are $3x^2 - 2xy + c$, square root of $1 - x^2$, $x + 6=0$. The purpose of the test was to ascertain the students' baseline knowledge.

During the implementation phase, the topic of linear and quadratic expressions, scheduled for two weeks in the mathematics scheme of work and four periods per week on the school timetable, was taught to the experimental and control groups. The researcher provided an example of algebraic expressions, along with guided practice. Variable and verbal expressions were as follows:

(a) Examples of linaer and quadratic expressions: (i) x increased by 6 is $x + 6$; and (ii) the quotient of 18 and n is 18/n
(b) Examples of verbal expressions: (i) $x/2$ is half of x; and (ii) $5n$ is five times a number, et.

The students were taught linear and quadratic expressions in a 40-minute lesson using eight periods throughout the two weeks. Following every lesson, students in the experimental groups solved quadratic expression exercise. Students solve questions on quadratic expressions from the New General Mathematics book for senior secondary school (Kalejaiye, 2023). The teacher supervised the students to check and ensure that they adhered to the guidelines on how to solve linear and quadratic expressions.

The items from the SMAT pre-test were rearranged for the post-test. After the computer game, the post-test was given to both groups to evaluate the students' learning. The tests were marked and graded.

Data Analysis

The collected data were analyzed using both descriptive and inferential statistics. First, the demographic information of the respondents is shown in percentages. The average and standard deviation indicate the pre-and post-test results. Mean, frequency counts, and percentages were used to provide answers to the research questions.

Ethical Procedures

Permission was granted by the ethical committee of the University of Ilorin, Kwara state, Nigeria, to conduct this study. The researcher consulted the principals of the chosen two schools before proceeding. Consent forms were completed by students in these schools agreeing to participate in the study after discussing the students' consent, objectives, and activities. The researcher ensured that all works cited were referenced and paraphrased. After considering all ethical issues, a plagiarism check was conducted on the study to ensure high originality.

RESULTS

The results of the study were presented in the following tables

Table 1.

What are the computer programmers' comments on the developed game on linear and quadratic equations using the ADDIE model?

Computer programmers' comments	No. of Respondents	Excellent	Very good	Good	Fairly good	Fair	Mean	SD
Legibility	10	6	4	0	0	0	2.63	1.11
Interface	10	4	4	2	0	0	2.83	1.19
Navigation	10	3	5	2	0	0	2.52	0.95
Functionality	10	6	4	0	0	0	2.48	0.88
Packaging	10	6	2	2	0	0	2.34	1.01
Typography	10	6	3	1	0	0	2.56	0.98
Durability	10	5	3	2	0	0	2.55	0.93
Total		36(51.4%)	25(35.7%)	09(12.9%)	00(00.0%)	00(00.0%)	2.55	

Computer Programmers' Comments on the Developed Computer Game

The ADDIE phases are significant because they improve collaboration among programmers, educators, and designers, resulting in an educational game that efficiently conveys mathematical concepts, making ADDIE a vital foundation for quality software development.

The result of the evaluation of the computer game on linear and quadratic equations by the computer programmers is in Table 1. Table 1 indicates the total number of respondents and the game's features evaluated. The Package was rated 60% in terms of legibility, functionality, packaging, and typography, while the durability of the Package was rated 50% high by the computer programmers.

From Table 1, the breakdown of the analysis is as follows: Total Response (Excellent) is 36 (51.4%), total response (Excellent) is 25 (35.7%), total response of (Good) is 09 (12.9%).

Based on the results, the excellent response is 51.4%, above the average. This implies that, with little or no modification, the Package could greatly help in simulating the teaching-learning process and serve as an excellent supplement to the teacher's verbal presentation of information in the class. It could also serve as a reinforcer to the students and motivate them to learn Mathematics.

Table 2
What are the mathematics teachers' comments on using the developed computer game on linear and quadratic equations in teaching?
Mathematics Teachers' Comments on the Developed Computer Game

Mathematics Teachers' Comments	No. of Respondents	SA	A	D	SD	NI	Mean	SD
Useful for instruction	20	12	6	2	0	0	2.64	1.04
Logically organized	20	13	7	0	0	0	2.60	1.04
Require reasonable time	20	6	5	5	4	0	2.64	1.09
Visualization	20	11	8	1	0	0	2.82	1.14
Understanding	20	9	8	3	0	0	2.80	1.08
Easy to navigate	20	14	6	0	0	0	2.42	1.05
Enjoyment	20	12	7	1	0	0	2.71	1.06
Need more topics	20	15	5	0	0	0	2.62	1.05
Easy of use	20	12	8	0	0	0	2.80	0.96
Adequacy	20	12	7	1	0	0	2.51	1.07
Total		116(58%)	67(33.5%)	13(6.5%)	04(2.0%)	00	2.65	

Table 2 shows that the total number of respondents was 20. It revealed that Mathematics teachers felt strongly that the computer game on linear and quadratic equations instructional Package would be helpful for instruction in teaching and learning Mathematics. From Table 2, the breakdown of the analysis is as follows: Total Response (Strongly agree) is 116 (58%), total response (Agree) is 67 (33.5%), total response (Disagree) is 13 (6.5%), total response (Strongly disagree) is 04 (2.0%).

Table 3
How does the developed computer game affect students' mathematics achievement on linear and quadratic equations?
T-test for Independent Measures showing Comparison of Computer Game and students' mathematics achievement on linear quadratic equation

	Computer Game	N	Mean	SD	Df	T	Sig
Student Mathematics Performance	High	31	19.12	2.66	58	-4.240	.000
	Low	29	14.08	2.28			

Table 3 present results on the difference between high and low computer game on students' mathematics achievement on linear quadratic equation among secondary school students. It is shown that computer game had significant influence on

students' mathematics achievement on linear quadratic equation among secondary school students [t (58) = -4.240; p < .01]. Further, secondary school students with high level of computer game ($\bar{x}$ = 19.12; SD = 2.66) reported higher level of student mathematics performance than those with low level of computer game ($\bar{x}$ = 14.08; SD =2.28). This is because involvement in computer game by students requires high level of creative ability

Discussion and Conclusion

The package was developed to introduce supplemental material in teaching mathematics in particular. The game was also evaluated by computer experts and mathematics teachers, who believed it would reinforce and arouse the student's interest in learning mathematics.

Computer games appeal to students who shy away from participating actively in mathematics lessons for whatever reason. It also found the study that using computer games as a tool could help teachers teach Mathematics effectively and could, at the same time, expose students to the ability to solve problems in order to fulfill the requirements of the Millennium Development Goals.

From table 1, the breakdown of the analysis is as follows: Total Response (Excellent) is 36 (51.4%), total response (Excellent) is 25 (35.7%), total response of (Good) is 09 (12.9%). Based on the results, the excellent response is 51.4%, above the average. This implies that, with little or no modification, the Package could greatly help in simulating the teaching-learning process and serve as an excellent supplement to the teacher's verbal presentation of information in the class. It could also serve as a reinforcer to the students and motivate them to learn Mathematics.

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These findings are in line with those of (Chiu, 2022; Alsadoon et al., 2022 Saal et al., 2020), who supported that by using computers as an instructional tool, students showed greater interest and were motivated to learn linear and quadratic equations in Mathematics. It is also found that using computer software packages for Mathematics promotes students' problem-solving ability development.

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Two senior secondary schools in Nigerian were the only subjects of the investigation. The authors suggest similar research in other contexts. Studies comparing urban and rural senior secondary school students' mathematics achievement when taught through computer games are also recommended. The authors further suggest using online computer games in longitudinal studies to follow students' progression in learning mathematics.

Based on the findings of this study, computer game instructional Packages should be adopted as a medium for reinforcing students' learning of complex concepts in Senior School Mathematics. Mathematics teachers should welcome and accept computer games as a valuable teaching and learning tool. The government should provide computers for every school to expose students to their use, especially games relevant to Mathematics concepts. Teaching through computer game may result in students becoming more focused and willing to dedicate considerable time to engage in mathematics in the classroom. By involving senior secondary school students in computer game when teaching mathematics surely yields better mathematics achievement. However, teachers should extend this strategy to also impact students' attitudes positively when learning mathematics.

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