ASSEREN
Journal of Educational Research and Development
VOLUME 11, JUNE 2024 PAGE 38-49
ISSN: 2536-6899 E – ISSN: 2814 – 3248 Website: www.theasseren.org.ng

EFFECTS OF DIGITAL FORMATIVE ASSESSMENT SYSTEM ON SECONDARY SCHOOL STUDENTS' MATHEMATICAL CONCEPTS AND PROCEDURAL KNOWLEDGE RETENTION IN ABAK, AKWA IBOM STATE

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Submitted: 9 December, 2023 Revised: 22 May, 2024 Accepted: 29 May, 2024

Abstract

Facing significant hurdles in implementing effective formative assessment methodologies, especially in areas with limited resources and connectivity, this research sought innovative solutions suitable for low-resource contexts. This study in Abak LGA, Akwa Ibom State, Nigeria investigated the effect of digital formative assessments on mathematics retention among secondary students. The study employed a independent group repeated design, the pretest, post-test, and retention tests serves as time points, across multiple treatments, aiming to explore the impact on students' conceptual and procedural knowledge in mathematics. Out of a population of 3,482 Senior Secondary 2 (SS2) students, 132 were chosen from three schools through purposive sampling, focusing on schools equipped for the research. The participants were divided into experimental and control groups, assessed using the Quadratic Equation Conceptual Test (QECT) and the Quadratic Equation Procedural Test (QEPT), both validated and showing reliability coefficients of 0.72 for QECTs and 0.75 for QEPTs respectively. Data analysis through descriptive statistics and repeated measure ANOVA revealed significant improvements in both conceptual $F_{(2, 129)} = 16.74, \rho < 0.01, \eta 2 = 0.22$ and procedural knowledge $F_{(2, 129)} = 25.04, \rho < 0.01, \eta 2 = 0.27$ among students exposed to the digital assessment strategies. The study concluded that digital formative assessments could significantly enhance the retention of mathematical knowledge and skills. Consequently, it recommends that schools incorporate valid, timely assessments tailored to the students' needs into the curriculum, along with necessary digital skills training to familiarize students with online, virtual learning and assessment environments.

Keywords: Mathematical Concepts knowledge; digital formative assessments; procedural understanding

Introduction

In recent times, every sphere of human society education inclucive, has been encapsulated by technology. This has brought about huge changes in diverse aspects of human activities in the 21st century. With the arrival of Information and communication technology (ICT), it is deemed necessary that diverse activities in education be carried out using the technology. Nevertheless, recently the advancement of globalisation has made Information and Communication Technologies an important part of human life. Almost all areas of human life such as medicine, social life, commerce, and education, have been influenced by ICT. The integration of Information and communication technology into the education system has led to major changes in the educational structure of many countries. Hence, ICT can be regarded as a strong force for global changes in the educational subdivision. The twenty-first century is delineated as a period of change and reforms. The use of technological tools to respond to questions, delved into novel areas, and discuss ideas with others, this has transformed students' learning, is influenced by new ways of distributing and disseminating information which has engulfed numerous sections of society including education (Jahnke, Meinke-Kroll, Todd, & Nolte, 2020).

The integration of technology into the classroom has the capability of changing the ways teachers teach and how learners learn (Aldon & Panero, 2020). Humes (2021) illustrates that learning science by students can engage them more in various scientific activities, andinvolving actively inpracticing them, with the help oftechnology. The process of assessing learners' progress has also been changedfrom a traditional method to a technology-based method. Technology resources serve diverse intentions in an educational system such asassessinglearning outcomes with the use of Computer Based Test (CBT) (Joshua, 2018), utilizing themto formatively assess learners, and several other purposes, such as getting across to many learners (Humes, 2021), motivating, engaging students, modifying lessons, providing feedback and scaffolding (Halaweh, 2021). As the world ofeducation continues to evolve towards individual, hybrid, and virtual classroom models, teachers' skills in assessingstudents have also improved. This changehas led to the use of technology as an assessment and feedbacktool and is beginning to change the way teachers evaluate studentlearning. Therefore, Nwoke, Osuji, and Agi (2017) argue that educational evaluationis very important, making it an important factor in improvingteaching and learning. This is because assessment for learning allowsteachers and students to understand their strengths and weaknesses in the teaching and learning process and teachers can use digital formative assessment to address students'misconceptions. Due to the development of technology, it has now become possible to takeindividualized, timed, andpersonalized lessons suitable for students' performance (Lu & Cutumisu, 2021; Tissenbaum & Slotta, 2019).

Digital formative assessment is the process of creating, sending, storing, or reporting student evaluation tasks using digital technology. By integrating digital communication tools, Learning Management Systems (LMS) tools, and other professional tools, digital formative assessment becomes a feasible, flexible, and long-term solution for more comprehensive data collection and analyses on student learning (Ibrahim, 2020; Ibrahim & Hudu, 2020). By documenting all modifications and learning objectives and utilizing student data for diagnostic purposes as well as the resolution of educational disparities, digital formative assessment also offers the chance to support 21st-century skills and lifelong learning. While all types of assessment of student learning are important, the need for digital formative assessment is particularly critical because learning needs to take place outside of the physical classroom, and teachers and parents need to understand whether students are absorbing the content that is delivered to them in formats that differ from the usual.

Digital devices, according to Humes (2021), provide teachers the opportunity to collect resources from online databases that links curriculum to country's standards; teachers are provided with numerousassessment activities and questions that are integrated into lessonunits and dynamic, complex aspects of cognition and performances are easily assessedby teachers through digital devices. Looney (2019) opined that a good number of the new technological devices are incorporated into various methods for the assessment of students' performances, which includes rapidity in assessing students' understanding; timeously targeting feedback; learning collaboration; assessing of higher-order thinking ability and training multifarious contexts learning of students over time. Integratingdigital devices into assessment has the capability of providing advantagesof formative assessment in a timeously and more useful manner for both teachers and students (Elmahdi, Al-Hattami, & Fawzi, 2018). Digital devices are helpful to teachersin the implementation offor mative assessment effectively by ensuring that feedback is more rapid, showcasing easy-to-use feedback, and providing opportunities for the assessment of students' knowledge of scientific phenomena in an interactive new way, (Adesina, 2017).

Formative assessment in digital form supports the development of skills and forms the basis of life-long learning, the capability, and ability to learn throughout a lifetime and in various situations such as when schools are closed, as well as data for detection and solution of educational problems (Hsu & Lin, 2020). It is also known as an assessment for learning and is usually conducted regularly and evaluates the student's progress through observations, tests, assignments, and feedback. However, Looney (2019), has observed that enough evidence has not been gathered to prove that students can learn Mathematics more effectively through the help of digitally-enhanced formative assessment.

Mathematics is said to be logical, reliable, and a growing body of concepts that makes use of specific language and skills to model, analyze, and interpret the world. It is a human activity that involves creativity, the discovery of patterns of shape and number, the modeling of situations, the interpretation of data, and the communication of ideas and concepts (Uko, 2021). Mathematicshas abstract conceptswidely spread around it, whichare the bedrock for thelearning of Mathematics and other disciplines in the future (Inekwe, 2019; Uko, 2021). These abstract concepts are essential becausestudentswill find itdifficult to understand further Mathematics concepts or theories if they do not understand these basic concepts (Uko, 2021). Learners of Mathematics are expected to have experiences that can enable them to engage with challenging tasks that address preconceptions and misconceptions; and acquire conceptual knowledge as well as procedural knowledge, so that they can meaningfully organize their knowledge, acquire new knowledge, transfer knowledge to new situations, develop metacognitive awareness of themselves as learners, thinkers, problem solvers, learn to monitor their learning and achievement (National Council of Teacher of Mathematics, NCTM, 2014; Uko, 2021).

Lack of conceptual and procedural knowledge is an obviousreason why learners struggle to understand Mathematics concepts (Habiddin & Page, 2021; Uko, 2021). Using both conceptual and procedural knowledge is therefore essential for learners to properly respond to challenges (Chen, Tsai, Liu & Chang, 2021). Conceptual knowledge is knowledge of Mathematical facts and properties that are recognized as being related in some ways while procedural knowledge is identified as the set of rules and algorithms used to solve Mathematical problems. According to Braithwaite and Sprague (2021),conceptual knowledge is a multifaceted construct that includes knowledge categories, relationships, principles, and representations while procedural knowledge is referred to as the knowledge of procedures for solving problems, such as step-by-step algorithms that learners are taught in school.

The theoretical rationale that constitutes the problem of this study is thatschools are focused on attempting to increase standardized assessment scores by spending more time on test preparation rather than focusing on studentmastery of concepts. Many schools are devoting more time and resources toward test preparation and administration in core content areas of reading, writing skills, and Mathematics at the expense of other important curricular areas (Fairman, Johnson, Mette, Wickerd, & LaBrie, 2018). Standardized assessment has become a way to evaluate students and teachers. Poor understanding ofstudents in both concepts and procedures of Mathematical problems is censured on misconceptions (Braithwaite and Sprague 2021). A Plethora of research has been conducted in recent years, on ways to improve students' learning and Mathematical knowledge, however, not enough evidence of success has been recorded (Alashwal, 2020; Aldon, & Panero, 2020; Almalki, & Gruba, 2020).

A student-friendly learning environmentthat arouses and motivates students toimprove and development of a broader scope of concepts, procedures, and metacognitive skills, as well as various cognitive processes is demanded by students in secondary schools. It is the belief of educators that assessments for learning strategies are accurate in the improvement ofconceptual and procedural knowledge of studentsasteachers are capable of identifying learners' misconceptions and sharing them with the learners (Bernal-Ballen & Ladino-Ospina, 2019; Uko & Uko, 2019). Cognitive science research emphasizes that for integrating conceptual and procedural knowledge, digital devices have a critical role in learning by facilitating the implementation of formative assessment strategies (Paiva, Reis, & Raquel, 2020). Selecting the appropriate materials and tools for digital assessments for learning can be challenging for instructors due to the abundance and variety of digital tools accessible.

This study aims to define the primary categories of these instruments and their particular applications. Teacher and student communications as well as collaboration are facilitated by existing communication tools such as Zoom, Microsoft Team, WhatsApp, telegram, mobile phone calls, and short message services. Learning Management Systems (LMS) tools such as Google Glass, Google Forms, Moodles, and Schoologies are used as a platform for posting questions, assignments, and submitted reviews. To facilitate self-directed learning through flexible lessons and to allow the delivery of video responses specialized tools like Dream Box Maths, Wootmaths, Recap, and Screencastifies have been developed. Technology is made more accessible by some service providers during the close of schools, opening doors to more effective usage of digitalized testing. Nevertheless, the real problem is the "digital divide", which occurs when a reasonable population of the world does not have access to computers and internet connections (Humes, 2021). To extenuate these challenges, improvements have been made in the development of new methods for digital formative assessment in lower connectivities and lower resource contexts. For example, mobile-based platforms with strong offline capabilities such as CELL-EDS and Ustad Mobiles can be combined with accessible content aimed at helping disadvantaged communities (like Rumie). Platforms for messaging have been adapted to facilitate the delivery and tracking of learning (such as WhatsApp Classroom, Messenger, and Telegram), making traditional disciplines less probing. In the short term, schools can adopt quick cost-effective, and low-cost solutions, such as sending pictures ofprojects and working with parents to give assignments (Robertson, Humphrey, & Steele, 2019).

Furthermore, Several challenges have contributed to the ineffective implementation of formative assessment in Nigeria. The poor practices and integration of formative assessment strategies by teachers into their teaching process are hindered by the fact that it consumes time, also class session times are restricted. Several research studies have recommended the incorporation of technology into formative assessment to mitigate these problems (Humes, 2021; Paiva, Reis, and Raquel, 2020; Rahman et al., 2021). This background information, therefore, constitutes the rationale for this research on how digitally planned formative assessment strategies can influence secondary school students' retention of Mathematical concepts and procedures in general and particularly in quadratic equations. In achieving this intended purpose above, two null hypotheses were formulated.

Hypotheses

Ho1: There exists no significant mean score difference in the Mathematics conceptual knowledge retention of students when comparison is made between time points and groups.

Ho2: There exists no significant mean score difference in the Mathematics procedural knowledge retention of students when comparison is made between time points and groups.

Methodology

This study adopted independent groups repeated design. The population for this study consisted of all the 3,482 Senior Secondary School (SS2) students in 11 public secondary schools in Abak LGA, who offered Mathematics. Three public secondary schools were purposefully selected in Abak LGA for the study. This was based on schools with the needed facilities for the study. Three intact classes of SS 2 with 43,44,45 students from each of the three schools selected were used for the study. A sample size of one hundred and thirty-two (132) Senior secondary two (SS2) students were selected for the study. Each of the three intact classes selected was designated to independent groups. The pre-test, post-test, and retention tests serve as time points and include three groups, distributed as: Group one given Digital Formative Assessment (DIFA), Group two given Formative Assessment (FA) only, and Group three given conventional methods.

The area of the study was the Abak Local Government Area of Akwa Ibom State in the South-South Zone, Nigeria which has thirty-one local government areas. Abak LGA has five clans which are; Abak, Afaha-Obong, Midim, Otoro, and Ediene clans. There are 11 public secondary schools in Abak LGA. Then, from each school, one Mathematics teacher who has qualifications and experience in teaching mathematics was purposefully chosen to assist.

The quadratic equation concepts test (QECT) and quadratic equation procedure test (QEPT) were used as instruments for data collection in the study. To abate remembering of the test items by the students, 10 pre- and post-conceptual tests, and 10 pre and post-procedural test items were developed by the researcher with similarities but do not resemble each other and the post-test was reshuffled and used to test for retention. All 20 items were adapted from textbooks relevant to quadratic equations and remodeled to suit the purpose of measuring the learning achievement of students in conceptual and procedural knowledge as well as retention of such knowledge. The items spread across all content of the quadratic equation themes in the syllabus. The test items were divided into three sections,10 multiple choice, 7 responses, and 3 conceptual and procedural knowledge problem-solving questions. Each question carries 5 marks and a total of 100% was gotten. The intervention groups were of three levels. Two of the groups had Digital Formative Assessment (DIFA) and Formative Assessment (FA) only after every lesson, whereas the group 3 was given the same monthly conventional non- Formative Assessment (CM). The pretest, posttest, and retention test constituted three levels of time points used as well. Students' scores from the quadratic equation-test were used for analyses.

The instruments for data collection: The quadratic equation concepts and procedure items were assessed for face and content validity. Experts in Mathematics education, educational technology, and computer science in both Akwa Ibom State University, public secondary school, and College of Education Afaha Nsit, were given the QECTs and QEPTs, for validation. They examined the questions' conformability with the textbook objective and test questions, as well as the readability and correctness of options. Finally, the corrections made by the experts were effected. Furthermore, the researcher pilot-tested the instruments for internal consistency and dependability to verify the instrument's reliability. The QECTs and QEPTs were piloted on 40 SS2 students in one of the schools in the study area that did not participate. A reliability index of 0.72 for QECTs and 0.75 for QEPTs, respectively was obtained using the Kuder-Richardson 20 (KR20) formula.

Three groups were involved in the study, which were DIFA, FA only and a CM groups. The pre-quadratic equation concepts and procedure knowledge tests were given to each of the control and treatment groups before the treatment commenced. The planned interactive assessment for learning activities was implemented after every lesson for the formative assessments only group. The goal was to develop a deep understanding of mathematical concepts and procedures using various examples of problems on conceptual, procedural knowledge and the feedback to help the teachers planned the next lesson but without assistance from digital devices for activity inside and outside of the classroom. The DIFA group was exposed to digitally arranged formative assessment exercises, that integrated the macro, micro, and symbolic components of teaching with all formative activities being supported by digital devices and software programs throughout the period of the study. The CM group received conventional end-of-the-month tests and assignments that were not formative in nature in the three weeks that the quadratic equation was taught. Desktop computers, projector screens, laptops, whiteboards, and smartphones were the digital equipment employed for the research. WhatsApp, Telegram, PowerPoint, and Mifi services were also utilized. The aim of using such digital device software was to make the formative assessment process easily utilized within and outside the class.

The teachers in collaboration with the researcher, used PowerPoint for the development of individualized formative assessment activities for the students. The teachers presented the lessons in the class on desktop computers using plasma screens. The students were given enough time by the teachers to deliberate on the formative activities throughout the research period. The researcher created a WhatsApp and Telegram group and added the teachers and the students. The teachers always give homework to be completed at home by students. The teacher uses the platform to correct the students for their mistakes individually outside of the classroom. The platform is also used by the teachers to link the necessary instructional activities, that will help the students developed their mathematical concepts and procedures understanding. All through the research period, students were given activities that evaluates higher-order thinking skills and urged them to reflect on them before responding. To realize this, the researcher through the teachers used formative assessment activities such as concept mapping, concept diagnosis, observations, self-assessments, quizzes, think-aloud, think-pair-shares, 1 question and 1 comment, three-minute puzzles, and one-minute essays as class activities. The post-conceptual and post-procedural knowledge tests were administered to the students at the end of the study, and after 2 weeks, the retention test was conducted in all groups to assess the effect of time points on each group.

The core goal of the project was precisely to observe the impact of digital formative assessment on students' retention of mathematical concepts and procedures. Data generated were coded and analyzed using means and standard deviations and repeated measures analyses of variance (ANOVA). This was used, to ensure that analyses are more authentic and dependable, given that, the variables is measured several times to determine the effects of the treatments or interventions. The necessary assumptions tests were conducted before the analyses.

Results

Ho1: There exists no significant mean score difference in the Mathematics conceptual knowledge retention of students when comparison is made between time points and groups.

To test hypothesis one, the aftermath of the descriptives and deductive statistics on the conceptual Knowledge Test are presented in Tables 1 and 2.

Table 1 for HO1: Pretest – Post Test of Students' Mathematical Concepts Knowledge test score Classified by 3 (Times) × 3 (Group).

Groups	N	Pre- test		Post- test		Retention		Mean difference
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	(Retention – Postest)
DIFA	45	7.86	2.45	18.95	2.31	28.37	2.75	9.42
FA	43	6.95	3.09	16.68	3.85	20.74	3.32	4.06
CM	44	8.28	2.48	12.65	4.07	13.97	3.23	1.32
Total	132	7.69	2.67	16.09	3.41	20.56	3.10	4.93

DIFA= Digital Formative Assessment; FA= Formative Assessment alone; CM=conventional method of assessment.

Table 1 shows pretest – post test of students' mathematical concepts knowledge test score classified by 3 (Times) × 3 (Group). Examination of result shows that there was a huge gain in the mean test aggregate between pre- conceptual test (M = 7.69, SD = 2.67) and the post conceptual test (M = 16.09, SD = 3.41). Moreso, a large increase exists between post-conceptual test aggregate (M = 16.09, SD = 3.41) and retention test scores (Mean = 20.56, SD = 3.10). Figure 1, shows the line graph pattern across time points for 3 intervention groups. The trend is raised in a straight line layout, and the 3 group directions showsimilarity. In all, the three groups varied, with the CM group not performing as well as the other two groups. Additionally, the mean improvement in the retention test of the 3 groups was greater than their test scores in the other two timeperiods. Comparing the mean difference scores of the three groups fromthe posttest to retention test, Digital formative assessment was the highest in enhancing students' retention with a mean difference score of 9.42, followed by Formative assessment only with a mean difference score of 4.06 and the conventional method was the least with the mean difference of 1.32.

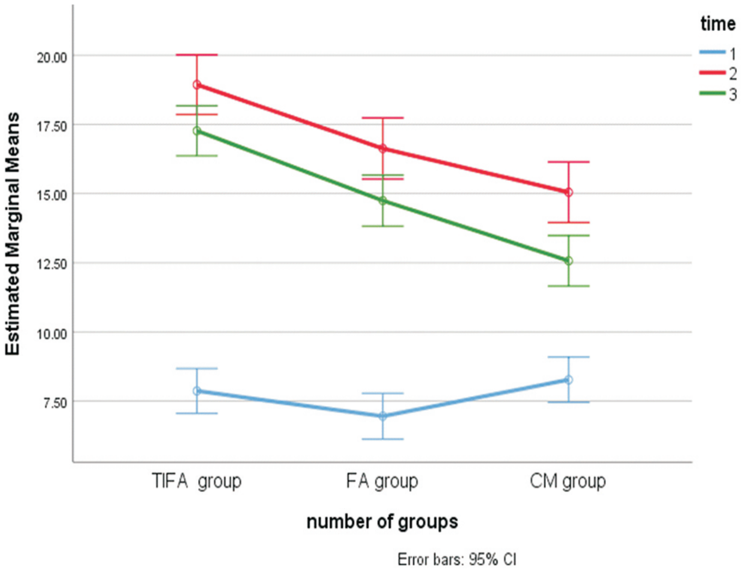

Figure 1: Line Graph Representing Students' Scores of the Conceptual -Knowledge Test at Different Time Points among the Groups.

Table 2 for Ho2: Results of Mixed Model Analysis of Variance for each Time Points By Groups on Mathematical Concepts Test Scores

Sources of variation	Type III MS	df	MS	F	Sig	η2
Between-subject effect Group	524.07	2	262.03	16.74	0.00	0.22
Error	2020.23	129	15.66			
Within-subject effect Time	6133.43	2	3066.72	419.03	0.00	0.76
Time*Group	343 .39	4	87.10	11.90	0.00	0.17
Error (time)	1888.15	258	7.32			

NS = Not significant at .05 level of significance; * = Significant at .05 level of significance

Table 2 shows results of mixed model analysis of variance for each time points by groups on mathematical concepts test scores. The result is a, 3 (times: Pretest, posttest, and retention test) × 3 (groups: DIFA, FA only, and CM) repeated measures Analysis of Variance on concepts knowledge test scores analyzed. The main effects and interactions between time points and between-group differences on repeated measures of students' concepts test scores were assessed. The results demonstrate the main effects among groups on mathematical concepts test scores were found to be significant with a huge effect size $F_{(2, 129)} = 16.74$, $\rho < 0.01$, η2 = 0.22. Also, the main effects of time-points of mathematical concepts test scores were found to be significant $F_{(2, 258)} = 419.03$, $\rho < 0.001$, η2 = 0.78. With a huge effect size. Again, there exist, significant interactions among time points and groups on conceptual-understanding test scores $F_{(4, 257)} = 11.90$, $\rho < 0.001$, η2 = 0.17.

Ho2: There exists no significant mean score difference in the Mathematics procedural knowledge retention of students when comparison is made between time points and groups.

To test hypothesis 2, the descriptives and inferential results on the procedural-Knowledge Test are presented in Tables 3 and 4.

Table 3: Pretest – Post Test of Students' Mathematical Procedurals Knowledge Test Score classified by 3 (Times) × 3 (Group).

Groups	N	Pre- test		Post- test		Retention		Mean difference (Retention – Postest)
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
DIFA	45	5.09	1.64	15.76	1.48	24.64	1.43	8.88
FA	43	3.39	2.62	10.42	1.46	15.32	1.49	4.90
CM	44	3.84	1.86	9.47	1.38	9.89	1.76	0.42
Total	132	4.11	2.04	11.88	1.44	16.61	1.56	4.73

DIFA= Digital Formative Assessment; FA Formative Assessment alone; CM= conventional method of assessment.

Table 3 presents pretest – post test of students' mathematical procedurals knowledge test score classified by 3 (times) × 3 (group). Assessing the descriptives data, it can be observed that the average gained in procedure comprehension test aggregate raised tremendously between the pre-test (M = 4.11, SD = 2.04) and post-test (M = 11.88, SD = 1.44). Also, from the posttest (M = 11.88, SD = 1.44) to the retention test (M = 24.64, SD = 1.56), an increase was observed in the mean gained inmathematical procedure understanding test scores. Again, it can be seen from the estimated marginal mean table, that the retentionmean r score for the mathematicalprocedure test is higher than the mean post as well as pre-procedural understanding test score. Regarding each time points, the average gain in the DIFA was higher than the average gain of the FA only and CM groups. Comparing the mean difference scores of the three groups fromthe posttest to the retention test, Digital formative assessment was the highest in enhancing students' retention with a mean difference score of 8.88, followed by Formative assessment only with a mean difference score of 4.90 and the conventional method was the least with the mean difference of0.42.

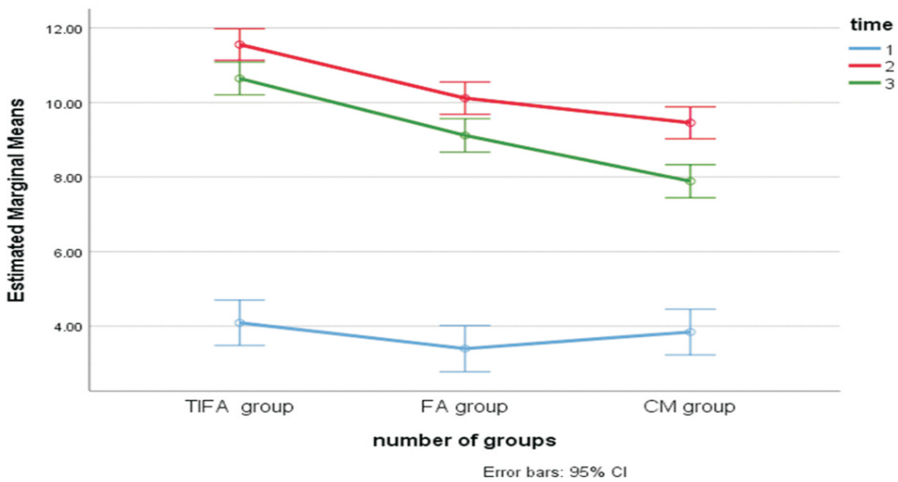

Figure 2 : Line Graph Representing Students' scores of the procedural knowledge test at different time points amongst the Group.

Table 4 for HO2: Results of mixed model Analysis of Variance for each time points by Groups on Mathematical Procedures Test Scores

Sources of variation		Type III MS	df	MS	F	Sig	η2
Between-subject effect	Group	205.89	2	102.95	25.04	0.00	0.27
Error		552.61	129	4.28			
Within-subject effect	Time	3277.36	1.32	2517.72	772.19	0.00	0.86
Time*Group		77.80	2.62	29.89	9.81	0.00	0.13
Error (time)		546.80	167.93	3.26			

NS = Not significant at .05 level of significance; * = Significant at .05 level of significance

The result in Table 4 is a, 3 (times: Pretest, posttest, and retention test) × 3 (groups: DIFA, FA only, and CM) repeated measures Analysis of Variance on mathematical procedure knowledge test scores analyzed. The main effects and interactions between time points and between-group differences on repeated measures of students' mathematical procedure-test scores were assessed. Mauchly test of assumption of sphericity for the procedural- test indicated a violation, W = ($\chi 2$ (2) = 16.9, $\rho < 0.05$); therefore, a correction on the degrees of freedom was madeusing Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.67$). The result in Table 4 revealed a significant mean difference was observed for mathematical procedure test scoreF (1.32, 167.93) = 772.19, $\rho < 0.001$. Significant mean differences exist among the three times point, F (1.32, 167.93) = 772.19, $\rho < 0.01$, and amongst the group, F (2, 129) = 25.04, $\rho < 0.01$, for mathematics procedurals test aggregate. A huge effect size was also observed for the groups and time periods. Interactions between time periods and groups were also found to be significant F (2.62, 167.93) = 9.81, $\rho < 0.01$. Effect sizes were large across bothgroups and times. However, an intermediate effect size for the interactions between times and group was observed. A follow-up of these interactions indicates no significant mean differences amongst groups and baselines in comparison to the two-times.

Discussion of findings

Mathematical concepts test aggregates showed a significant main effect between groups. Additionally, a significant interactions between times and treatment groups in mathematical procedure assessment scores was observed, A significant mean difference was also observed between the three-time points and treatment group. There were significant interactions between the time point and groups as well and a significant difference in the mean achievement of mathematics students after being exposed to digital formative assessment in favor of the DIFA group was also observed. A huge effect size for mathematical concepts and procedure test scores as well as for groups and time points was also observed. There is also, a large effect size of interactions between time points and groups.

Comparing the DIFA, FA and the CM groups, students in the DIFA and FA groups had a deeper understanding of the concepts and process content and were able to express ideas more clearly than the CM. The implication is that a digital formative assessment strategy in the class is capable of improving students learning and retention. The decision is supported by Matilda and Helen (2019); Hume, (2021), and Alashwal (2020), whose findings revealed that students benefit from formative assessment with reasons being that it helps in revealing problems associated with learning, difficult topics understanding, and also allows enhancement of students' learning outcomes. The results of this study also indicate that digital formative assessment activities may be effective in improving mathematics concepts and procedure retention among secondary school students. This is not surprising, as research shows that students who receive this type of feedback become motivated, engage more in learning, and begin to view the assessment activity as a tool for improvement (Paiva, Reis, & Raquel, 2020).

The main peculiarity of Formative Assessment that is related to its purpose is assisting learning. This is why FA is also called 'assessment for learning'. Assessment for learning represents a powerful tool that can enable teachers to build on learners' prior knowledge and matches their teaching to the needs of the learners so as to meet objectives of high-performance, high-equity of learners outcomes, and for providing them with knowledge and skills for lifelong learning. Data and information that is available daily in front of teachers should be used to drive instructions, which can be accomplished through integrating digital technology into formative assessments. DeFour et. al, (2016) sees teachers that are effective in teaching as those that are continuously using formative assessment to diagnose learners understandings and misunderstandings to know what next to do with instructions. Also giving credence to the findings of this study are studies by Kline, cited in Hume, (2021), Shore, Wolf, and Heritage, (2016) and Andersson and Palm (2018) who all agreed that integrating digital technology into formative assessment demonstrates positive effects of formative assessment on student achievement. They also iterated that digital formative assessment, having a process-oriented activities, with appropriate planning time, provides possibilities for the teachers as well as the students to actively engage in the activities as self-regulated learners in a collaborative and supportive environment.

Although some researches agrees that technologies could foster deep-seated learning and provide evidence of learning outcomes (Humes, 2021), it is not without its problems. Some of these issues may be due to differences in the way technology is used or the way teachers use technology (Paiva, Reis, & Raquel, 2020), but again, there is a need for a better understanding of the interaction between teachers, students, technologies and how they support formative evaluation.

Conclusions

Digital formative assessment strategies effectively improve secondary school students' performance and retention of concepts and procedures in mathematics generally and quadratic equations in particular. The finding that there was a significant difference between the pre-test, post-test, and retention-scores of the experimental group and that this difference favored the post-test scores also confirmed this situation. Most importantly, digital formative assessments should be designed to assess student achievement immediately, be able to complete the assessment over time and allow for continued measurement of education despite future crises. The teaching and learning of twenty-first-century skills can be enhanced by the widespread use of digital formative assessment.

Recommendations

1. School/ management, governments, and stakeholders should invest in helping students and teachers acquire more advanced digital skills.
2. Schools should ensure that testing is effective, timely, appropriate, and relevant to students' learning needs, and should seek to build digital skills into the curriculum so that students can learn not only through virtual learning but also through testing.
3. The government should develop policies to address the digital gap and data protection issues be addressed.
4. Teacher's continuing development programs should focus on abilities and skills in developing effective formative assessments and skills in data analysis.

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