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THE DESIGN AND DEVELOPMENT OF A LEARNING STRATEGY TO ENHANCE STUDENTS' ENGAGEMENT IN SIMULTANEOUS EQUATIONS: AN EVALUATION VIEWPOINT

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Abstract

Abstract: In the 21st century, teaching and learning mathematics courses witness significant expansion and development of technology use, which creates a shift from teacher-centred to student-centred learning engagement. Student engagement (SE) faces many challenges of poor performance and student difficulty in solving simultaneous equations involving indices (SEII), among others. This paper presents an evaluation viewpoint of the learning strategy (LS) with cooperative learning strategy (CLS) and GeoGebra (GG) integration to support SE in SEII. The LS employs the think-pair-share approach and the six (6) principles of learning phases associated with constructivism ideology. The discussion of the preliminary mathematical achievement test (MAT-test) from pre-and post-tests with 41 students who have learned SEII using the developed LS is also presented. Semi-structured interviews were conducted with three experienced lecturers to provide feedback and recommendations on interacting with LS. The themes that emerge from those lecturers include the connection between LS phases, specific material, cooperative activity, playfulness in the discovery process, and thinking. Experts' feedback on the LS's content reasoning and content learning strategy through a questionnaire was tested using Fleiss multi-rater Kappa and showed good inter-rater reliability and agreement between them. The estimated marginal means covariate of the ANCOVA test was then examined, and the results supported the necessity for a learning strategy to be developed. The findings revealed that the LS, with CLS and GG integration, has the potential to be educationally effective in enhancing SE in SEII.

Keywords – Learning strategy, Students' engagement and technology.

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1. Introduction

Students' engagement (SE) is a multidimensional paradigm that includes a variety of distinct but highly connected mathematical tasks, use of technology, tools, or active participation in a learning activity (McCulloch, Hollebrands, Lee, Harrison & Mutlu, 2018). Attard (2012) stressed that emotional engagement or effective refers to an approach concerning student interest in and out of the classroom. Alongside, SE involves learners' participation in a mathematical task connected to technology. Zulnaidi and Zamri (2017) argued that engagement is a component of learning by using equations, tables, graphs, numbers, manipulatives, and formulae through a particular activity that may connect numerous real-life concepts. Student engagement is the amount of time and effort devoted to their success and other activities (Heaslip, Donovan & Cullen, 2014). Dropout and completion are long-term processes of engaging or disengaging from school, not actual events (Christenson, Wylie & Reschly, 2012). Students worked well with their peers throughout group tasks and compared notes (Aliyu, Osman, Kumar, Talib & Jambari, 2022). Also, each project allows for active learning, whether it focuses on principles, applications, or methodologies. The rationale for enhancing students' engagement is to inculcate a higher level of academic performance, increase their motivation to study, encourage them to explore their surroundings, enable them to learn on their own through activities created by higher-quality learning, and decrease the loneliness that children may experience during learning engagement (Martin, 2018). The students' engagement faces many challenges and requires attention from the stakeholders to fix the arising issues like difficulties in relating mathematical structures that involve terms and symbols from conventional methods; learning and simplification of simultaneous equations involving indices (SEII) (Ugboduma, 2013). Usman (2019) argued that there is poor student performance in mathematics of below 50% between 2014-2018 and when answering simultaneous equations simultaneously in Nigeria, among others (Chief Examiner's Report, 2018). Specifically, the candidates failed to appropriately use the rules of indices when asked to generate two simultaneous equations and solve for the values of x and y. The research findings may aid future college mathematics students in enhancing their learning methodologies and integrating technology during the transition from expert to student. Future researchers will develop ways for comparable investigations to improve mathematical reasoning and build on this work's findings by using different educational levels. The LS developed may be recommended and re-examined for conversion to mathematics chapter contributions (textbooks) at the junior secondary school level as content material based on the suggested guidelines from stakeholders for future student use.

SE's difficulties in the twenty-first century lie in how to do away with students' abilities and passions, their strong work ethics, desire for academic success, and openness to trying new approaches to problems (Niemi, Niu, Vivitsou & Li, 2018; Warner & Kaur, 2017). Also, focus on students' creativity in problem-solving and provide them with specific instruction problems and logical thinking (Imms & Byers, 2017). Also, using the suitable concept and approach to create a well-explained and easy solution process. Thus, the use of formulas and languages in mathematics learning can make a crucial contribution to the application and development of the world around us (Etuk & Bello, 2015).This demonstrates that students recognise the significance of SE in their lives and future in tasks related to practical and theoretical understanding in mathematics. The link between the classroom and the outer world as a source of entertainment, discovery, fun, and teamwork. Veiga, Reeve, Wentzel and Robu (2014) stressed that SE promotes good feelings such as curiosity, interest, and delight to learners. Additionally, the finding may boost critical thinking skills, address issues related to, simplification, and learning difficulties faced by Nigerian students. Similarly, to inspire the federal government of Nigeria's vision and mission 20:2030 on access to quality education for learners and nation-building development through technology use. Also, the college students may use the designed learning material for the junior secondary school course content as a mathematics chapter contribution textbook at the departmental level and produce journal papers.

The development of the learning strategy was based on the ADDIE instructional design model. This paper discusses an evaluation point of view of the learning strategy developed, which is a part of the phases in the ADDIE model. The learning strategy developed to enhance the students' engagement through a cooperative learning strategy and technology integration (GeoGebra) may facilitate the task activity acquisition and give

the readers a better sense of the meaning of the learning strategy. Cooperative learning strategy (CLS) and GeoGebra (GG), GG, and CLS are examples of three categorical learning techniques that students use when solving simultaneous equations involving indices (SEII) in this context. The research uses this method to support team members' skills, learn in a small group, think-pair-share, and enhance division of labour in learning engagement. Li (2013) stressed that cooperative learning (CL) is an educational method in which students work together in small groups to accomplish a shared goal and each learner is accountable for his or her own and the group's success as well. All students face challenges in collective and fun learning environments, and the amount of time and commitment they can display is very likely to increase (Li, 2013). Also, CL accelerates social acceptance, enhanced mathematics attainment, increased self-esteem, and inter-group relations (Talib & Kailani, 2014). CL supports specific knowledge, skills, and the approach in which students build up their problem-solving competencies (Zengin & Tatar, 2017).

GeoGebra promotes exploring and conjecturing in mathematical problems as they draw and measure. GeoGebra is an open source software for all, easy-to-use and multi-platform dynamics for the classroom or home use, specifically to change the learning challenges in SEII for a better result. Mudaly and Fletcher (2019) argued that GG and CLS are associated with a goal and activities of students' learning issues and improve teamwork and the conjecturing of knowledge results. GeoGebra (GG) can easily be used to connect the geometry and algebra environment thereby providing a wide range of helpful features for students to use as a tutorial lesson (Saputra & Fahrizal, 2019). GG promotes critical thinking skills through sharing in the platform for mutual understanding of views, ideas, and opinions of the members and receiving feedback immediately (Alqahtani & Powell, 2017). Mudaly and Fletcher (2019) argue that GG can enhance teamwork and the conjecturing of knowledge findings in 2D and 3D dimensional shapes. Saralar, Işiksal-Bostan and Akyüz (2018) stressed that GG enhances the discovery of mathematical information freely and can motivate students to develop thought. Thus, GG is effective in learning calculus, and using GG might ease the learning of geometry, algebra, and calculus (Zulnaidi, Oktavika & Hidayat, 2020). Students' learning achievement in studying functions and drawing graphs improves when they use GG, according to statistical research (Aliyu, Osman, Daud & Kumar, 2021). Also, in this research, a learning strategy with CLS and GG integration is expected to enhance the development of learners' skills and abilities in learning SEll.

The Basic Science Technology Curriculum (BSTC)'s impact as a pivot on Nigerian mathematics learning has been designed and monitored greatly in appreciation of mathematics' importance in attaining the country's objective of rapid technological and scientific advancement. As a result, Effiom (2017) recommends that the government invest heavily in the triangle of mathematics, technology, and science. Mathematics has a significant impact on society, science, and technology currently. Although the usage of technology in our environment may be modest and unnoticed at first, it has had a substantial impact on our environment in different ways (Effiom, 2017). Many schools of education rely heavily on mathematics, and students' success is primarily determined by their ability to combine mathematics with teacher preparation by sustaining and reinforcing the integrity and quality of teacher education and making it worthy of civic assurance.

The basis for choosing simultaneous equations involving indices was based on the report from the West African Examinations Council Executive Summary of entries and results of 2018. The Chief Examiner's Report (2018) outlines a few of the challenges students encounter when attempting to solve problems involving probability, conceptual and procedural understanding with regard to converting word problems into mathematical statements, mensuration problems, and simultaneous equations involving indices. Also, numerous other subjects covered in the curriculum and real-world scenarios, particularly in the sciences, computer science, and engineering, are significantly influenced by simultaneous equations (Johari & Shahrill, 2020).

Simultaneous equation involving indices (SEII) is one of the mathematical topics taught in Nigerian colleges of education as enshrined in the minimum standards and specifically in General Studies Education (GSE) 113 as a compulsory course to all students in the college and Junior Secondary School

content called Math 224 for students of the mathematics department only as a core subject. Bessong, Ubana and Udo (2013) argued that the choice of the learning is constrained to a mode coupled with facilities of instruction characteristics of the perfect representation of mathematics learning controlled in the National Commission for College of Education (NCCE) minimum standard for mathematics. Designing a learning strategy with GG in the learning of simultaneous equations could be one of the vital fundamentals to support students to improve their learning milestones. Berger and Karabenick (2011) stressed that there are four motivational strategies and components of value in learning simultaneous equations are: (a) focus on learning and doing mathematics problems; (b) students' achievement; (c) usefulness to their future; and (d) rate of SE. Besides, to improve students' mathematical learning strategy in SEII, the learning ought to be stimulated through the technological integration approach rather than conventional methods that force learners to memorise content that they do not understand (Nordin, Tengah, Shahrill, Tan & Leong, 2017). Consequently, to promote students' enthusiasm and interest, hands-on discovery, which may build the development of learning abilities beyond direct familiarity, as well critical thinking. are an essential proficiency and a fundamental goal of advanced instruction (Shida, 2019). The students should be inquirers rather than receptors of procedures and facts, and assimilate into their learning the use of manipulatives, technology, pedagogy, and other resources that facilitate and ease learning difficulties.

Expert evaluation is chosen to provide explicit corrections and recommendations for issues and strengths observed from the developed learning material for improvement. The primary objective of the study is to design and develop an LS for the college students (F.C.E Zaria) in Kaduna state specifically. The LS is designed to make links in students' engagement with CLS, GG, and CLS with GG integration in trying to get rid of the problem discussed earlier in the background to the problem and at the same time to answer the objectives of the study. The objective of this paper is to discuss the evaluation viewpoint of the LS with CLS in SEII and GG integration that inspires cooperative learning and technology use.

2. Problem Statement

In most Nigerian schools, the LS with CLS in SEII and GG integration approach is new, prompting a request for more rigorous instructor training, such as the effective implementation of the Basic Science Technology Curriculum (BSTC) in Kaduna State to revive learners' engagement. Safiya (2021) stressed that the existing pedagogical style in Nigerian (Kaduna State) classrooms is insufficient in preparing students for the modern age of science and technology (Safiya, 2021; Abdurrahman, Abdullah & Osman, 2020) ICT integration can help students overcome learning challenges and improve information acquisition approaches. Thus, a concern among Nigerian mathematics students is the lack of an adequate approach to mastering SEII. Ugboduma (2013) stressed that secondary school students' inadequate learning of simultaneous equations involving indices (SEII) has threatened the very essence of academic achievement in the West African Senior School Certificate Examination (WASSCE). Jega (2017) stated there are issues with learning SEII, such as locating unknowns in equations. Confusion surrounds simultaneous expression and time-consuming issues due to inaccurate constant values and the abstract form of simultaneous equations related to letters that represent unknowns in the general solutions (Wang, 2015).

Consequently, to bridge the gap, three different learning strategies are introduced for meaningful, active mathematical engagement, creativity, and the development of learning skills. Design and development of learning strategies are one of the current approaches that can change this condition. Also, there is a link between classroom subject and real-world application by allowing students to absorb information through challenging assignments that simulate scenarios for the students to meet up in both informal and formal classroom settings (Hwang & Taylor, 2016). This paper provides information for researchers looking into the LS with CLS and GG approaches to algebra and mathematics. The LS uses the link in think-pair-share and social constructivism phases in promoting active mathematics classroom engagement. Thus, teachers may use the LS to identify the difficulties in teaching SEII and algebra. Also, the developed LS through social learning tools like slides and videotapes may assist learners. The interaction between above-average and below-average learners in the design might increase self-confidence.

3. Research Procedures

This part of the paper concentrates on activities that occurred as part of the investigation plan carried out in the following order: development of the learning strategy using the ADDIE model and objectives based on the links between students' engagement and learning strategies.

3.1. Development of Students' Engagement Learning Strategies through ADDIE Model

The ADDIE model is a five-phase model: Analysis, Design, Development, Implementation, and Evaluation. The five-phase cyclical procedure is used in both online and traditional training, or it can be used as a universal instructional pattern that provides a systematic approach to utilisation of instructional resources.

The rationale for using the ADDIE model rather than other models is to design and develop a learning material for course content that students can use to enhance their learning challenges in SEII. The model has a good pattern for the instructor to know what to do at each step. There is room for revision and evaluation at each step to fix the identified problem. The model is suitable for offline and online teaching, assists in learners' engagement, and comprehends different frameworks, unlike other instructional design models. The ADDIE paradigm improves learning by breaking it down into phases, each with its own set of functions, modification, formative, and summative assessment. The target audience, topic, goal, and needs are the emphasis of the analysis stage. The analysis phase focuses on choosing the material, the goals, and the learning difficulties. The design phase concentrates on grouping the learning objectives and resources. The development phase is done by stimulating lessons and incorporating SEII for classroom use. The implementation phase is to provide students with access to learning resources while the evaluation phase determines whether the developed LS is effective.

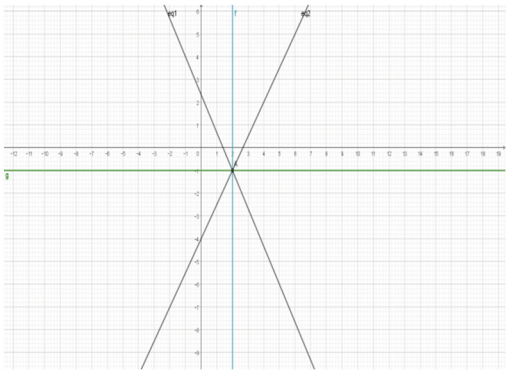
Also, for the creation of educational materials, developing a learning programme entails putting together the foundation as well as creating and assembling components. The educational materials that give users support are referred to as implementation. The evaluation's importance lies in determining the effectiveness of the learning materials as well as identifying alterations and modifications to the learning method. Thus, the focus of this paper is on the parts of the two final stages of the ADDIE model: implementation and evaluation by experts, after the first three stages are executed. Thus, the focus of this paper is on the parts of the two final stages of the ADDIE model: implementation and evaluation by experts, after the first three stages are executed. The aim is to get students' responses and feedback on the learning material developed and then to answer the relevant research question. Refer to Table 1 and Table 2 for the results of experts based on the content reasoning and content learning strategy. A module based on the Nigerian national curriculum for colleges of education's minimum standard was utilised to accomplish the goal. Hess and Greer (2016) stressed that ADDIE stands for any activity-based technique to expand on the instructional subject matter.

3.2. Objectives Based on the Links between Engagement and Learning Strategies

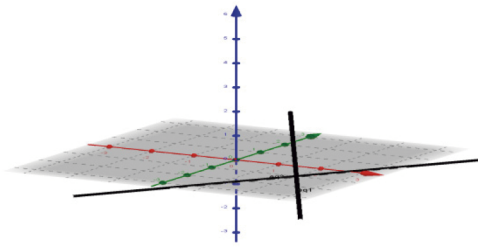
The developed LS's activities are carried out through reasoning and questioning by a paired small group through their team leader in the problem-solving tasks using technology and shared instruction derived from learning principles via conversation, expressing their thoughts, raising concerns, contesting ideas, engaging in independent discussion, and defending ideas. The students are expected to learn, make various links, and differentiate between activities in different environments such as cooperative learning strategy (CLS) with GeoGebra (GG). From the developed LS, in activities 1-3 via CLS and GG environment, the learners' type and read the intersection of the curve in SEII and connect think-pair-share with the six (6) learning principles phases to arrive at the final answer. Also, in activities 4-5, the scenario is demonstrated in three-dimensional graphics for discovery, entertainment, and play. In activities 1-3 by means of GG, students can type the SEII equations using the input bar and press enter. Also, they can accept the final solution by reading the point of intersection of the curve from the computer screen and connecting it to the six (6) learning principles phases. By displaying the scenario in 3D in a GG setting, students in tasks 4-5 they can visualise the two equations in SEII, make discovery, have fun, and play for a better

understanding of the SEII. In activities 1-3, through CLS the students are engaged by conventional answering (handwritten and graph) entering the SEII equations by means of tables of values, reading the curve relationship in SEII via graph, and connecting the think-pair-share with the six (6) learning principles phases to get the required result. Thus, the entire scenario in the three learning strategies above is summarised in Figure 1 and Figure 2 below via the photo type of SE with technology, hand-written and graph environment:

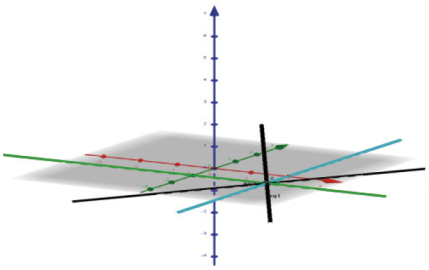
Festus (2013) emphasized that cognitive, metacognitive, emotional, and classroom resource classifications to categorize learning processes. Additionally, the focus of research on effective mathematics education is on instruction that promotes student engagement and activity. To adopt the new instructional approach, teachers must move away from lecturing and toward activity-based learning (Huei, 2015).



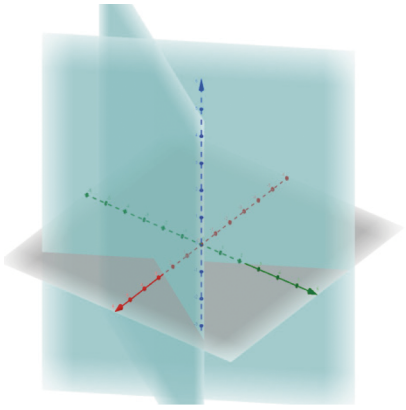
(a) Algebra view in GG



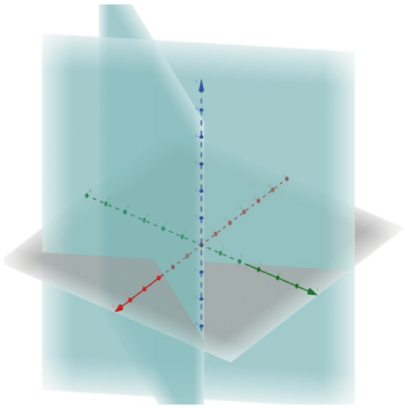
(b) 3D graphic by axes in algebra view with GG



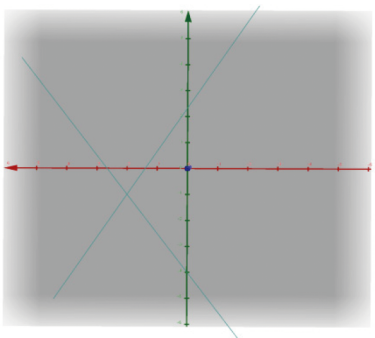
(c) 3D graphic by grid in algebraic view



(d) 3D graphic by axes in a plane



(e) 3D graphic by grid in a plane



(f) Fun play along x and y axes in a plan

Figure 1. Students' engagement with GG

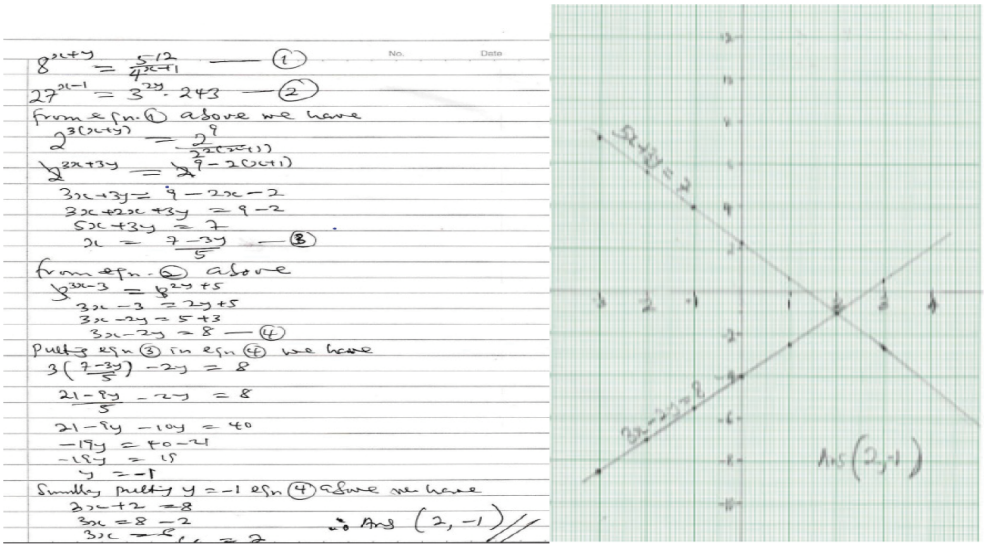


Figure 2. Students' engagement with handwritten and graph

4. Methodology

This segment explains how to carry out the coherent and detailed procedure to produce accurate, authentic facts that satisfy the purpose and results utilizing the mixed-method data gathering instruments from expert validation methodologies and pre- and post-preliminary findings. Daoud, Starkey, Eppel, Vo, and Sylvester (2020) argued that quality assessment in research procedure is paramount and includes qualitative, quantitative, or mixed method studies with empirically supported findings that have been peer reviewed in journals and theses. The data collection for this study uses both quantitative and qualitative data. Stage I: expert validation that comprises content reasoning and content learning strategy, and experienced lecturers 'verbatim interview. Stage II: by administering pre-and post-tests to students using the preliminary study result, quantitative data were obtained to verify the effectiveness of the learning strategy (LS). In LS with CLS in SEII and GG integration, learners' main concern should come first for a classroom learning to be effective. The discussions focus on problem identification, the preliminary study, and how SEII can be designed and developed using the ADDIE model. To ensure ethical practice in designing and development of learning strategy, the five phases of ADDIE model were used accordingly. The rationale of using the model is to produce and implement instructional learning material that can ease the student difficulty in SEII and promote the ethical standard in learning. Lior (2013) emphasised that the ADDIE model is widely employed in the development and implementation of instructional training programmes. In the ADDIE model there are five phases, Analysis, Design, Development, Implementation and Evaluation. However, to ensure that LS with CLS in SEII and GG integration obey the link between the structure of LS with CLS and the overall activities in the ADDIE model phases of learning in SEII, based on the content and objective of the junior secondary content, guidelines were used at all the levels of CLS in SEII and GG integration in every lesson activity and are provided in Figure 3 and Figure 4 below:

A purposive sampling of forty-one (41) students participated in a preliminary study to determine the effectiveness of activities and the quality of the learning strategy before its final deployment. The content of the module and the lesson activity were shared and reviewed to provide feedback based on the links made between the learning strategies and the principles of learning via social constructivism ideology. This was done to identify any necessary modifications, difficulties, or problems before the actual implementation of the LS. Three raters evaluated the LS based on content and the strategy used through Fleiss kappa multirater. Values in Fleiss kappa multirater may range from -1 to 1 (Denteneer, Van Daele, Truijen, De Hertogh, Meirte & Stassijns, 2018). The range of agreement is as follows: 0.20 = poor, 0.21 – 0.40 = fair, 0.41 – 0.60 = moderate, 0.61 – 0.80 = good and 0.81-1. 0 = excellent. Three mathematics lecturers were interviewed to acquire opinions and suggestions concerning the developed LS. By assigning

codes to the interview transcripts and grouping together different code categories, we led to the creation of themes (Lipovec & Mesarec, 2020).

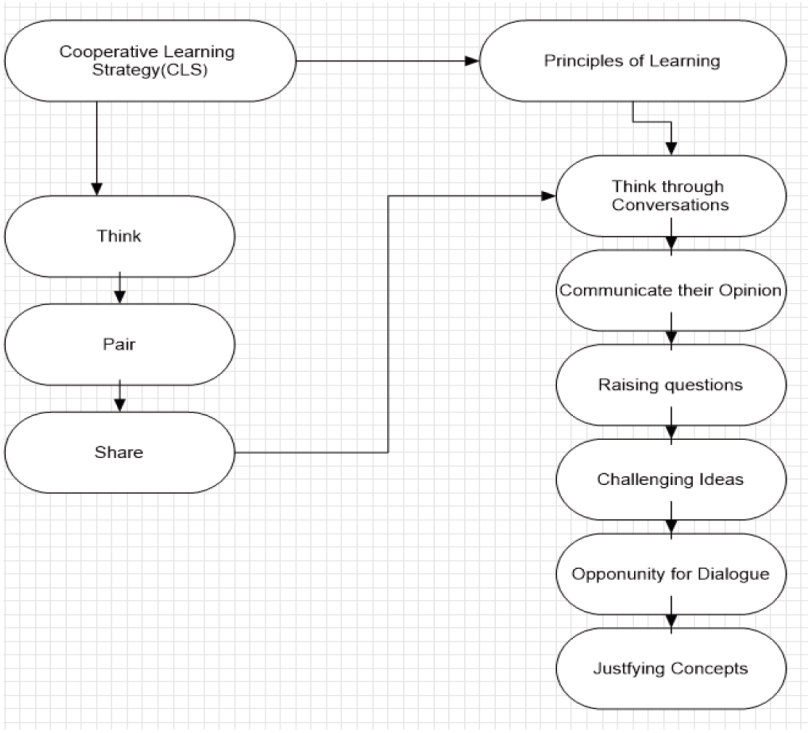


Figure 3. CLS link with principles of learning phases

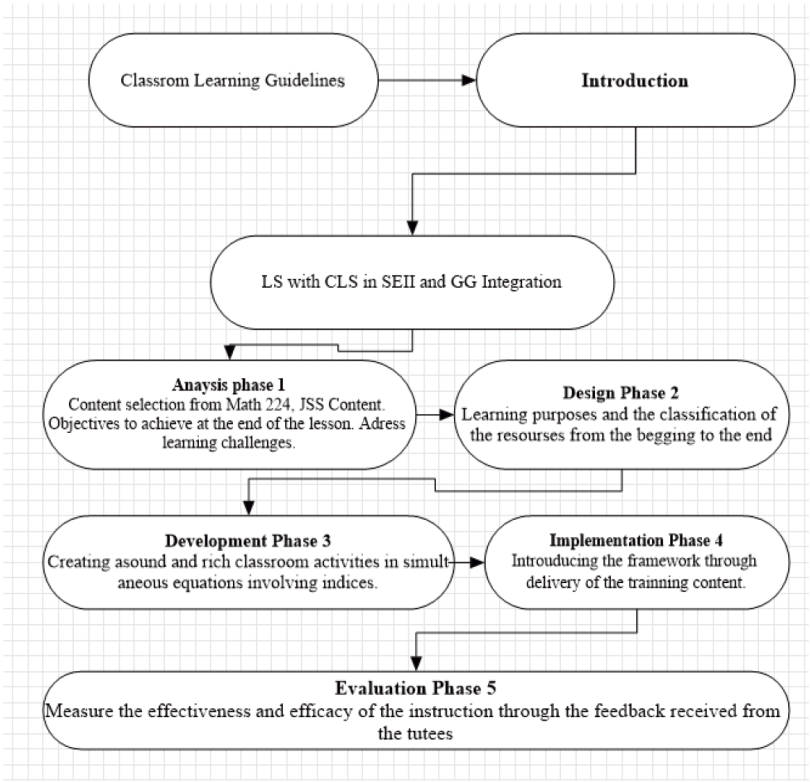


Figure 4. ADDIE model flow chart

4.1. Data Collection Technique (Instruments and its Validation Process)

The validity of a module can be obtained through the conduct of simple analysis to regulate the quality and effectiveness of the learning strategy developed in a classroom activity (Wahab, 2017). Therefore, evaluation forms were offered to experts to rate the content, based on its purposes, adequacy, student-centred working in a small group, the integration of GG with strategy, and also based on lesson activity organisation that covers links between the learning principles in constructivism ideology and the cooperative learning strategy that focuses on discovery and self-determining learning in the activities, and organisation in the link of the phases in LS with CLS and GG integration. The mathematics achievement test (MAT-test) was established to work with numbers, modify them, and connect them to ideas (Nizoloman, 2013). Thus, the MAT test was used in the pre-test and post-test of this study, where 10 multiple choice questions were adopted. Creswell (2014) stressed that conversation of data gathering should advance the focused sampling method and the procedures of data to be composed with interviews, comments, audio-visual resources, and documents. There were 295 students from seven different combinations in the mathematics department of the Federal College of Education in Zaria, Nigeria. In this preliminary study, forty-one (41) students were selected through a purposive sampling method for pre- and post-tests via MAT-test, who were subjected to experimental groups (14 × 2 students) and a control group (13 students). Interviews were then conducted with three experienced lecturers (experts in mathematics education with doctorates). Their ranks and areas of concentration vary. They are a senior lecturer with a focus on mathematics education research; a principal lecturer with a specialisation in technology; and a chief lecturer in cooperative learning from the Federal College of Education in Zaria, Nigeria. They were asked to evaluate the content reasoning and content learning strategy via a questionnaire, and the answers were then subjected to Fleiss Multirater Kappa for interrater reliability.

According to Curry (2016), qualitative research examines how people build reality in their relationships with others. All interviews were transcribed verbatim and checked. Transcriptions were then divided into units of analysis (quotations) that consisted of discrete ideas expressed by the participants. For each of the codes, the selection of quotations assigned to that code was then examined to identify common themes. Once themes were identified, summaries were written for each code (McCulloch et al., 2018). A detailed explanation of the data analysis results is presented in the following section of this paper.

5. Results and Discussion

The issue of expert selection arises because not all people who can assess content have the same set of skills. An expert assessment technique specifically makes it possible to attain objectivity. As a result, Vveinhardt and Gulbovaitė, (2016) stressed that authorities could supply the most substantial amount of pertinent information and who had specialized expertise, experience, and know-how primarily related to the subject of the specialist evaluation item chosen. The experts were consulted and had the chance to comment on each statement, table, and figure or activity from the instrument to make observations and suggestions. Thus, they could emphasize and highlight the emergent corrections based on the advantages and disadvantages of the current documents before presenting the learning strategy to the students. The experts' responses were subjected to Fleiss Multi rater Kappa to determine the interrater reliability of more than two raters in content reasoning and content learning strategy, as illustrated in Table 1 below:

Rahi (2017) argued that sampling setting describes a frame where a sample of the target populace can be drawn. Table 1 above illustrates the individual and overall agreement of the evaluation from three raters with the moderate outcome of .444 Fleiss Kappa at .85 significance value and the 95% asymptotic confidence between the lower and upper bound of .428 and .461 interval, which demonstrates good assessment. Thus, Falotico and Quatto (2015) stressed that one of the most used metrics for measuring multiple-rater agreement is the Fleiss Kappa. Besides, it reveals that the organisation of the content is aligned and appropriate with the purpose and offers students the chance to learn on their own in a small group via shared activities and use of technology with the learning strategies involved in the lesson

activity. Table 2 below illustrates content and lesson strategy via Fleiss Multirater Kappa interrater reliability:

Table 2 above illustrates the individual and overall agreement of the evaluation from the three raters with the substantial outcome of .732 Fleiss Kappa at .005 significance value and the 95% asymptotic confidence between the lower and upper bound of .716 and .748 interval, which demonstrates good assessment ratings. Consequently, it demonstrates that the content and lesson activities organisation in LS with CLS in SEII and GG integration is appropriate with the lesson objectives; the relationships between the phases are also appropriate. Moreover, those activities in the LS with CLS in SEII and GG integration inspire cooperative learning, technology use, and small group learning that leads to discovery. Similarly, the material used in the activities and organisation of the stages are companionable (Nasiru, Abdullah & Norulhuda, 2019).The expert input indicates a moderate and substantial outcome with respect to the content reasoning and content learning strategy from the evaluation and three raters.

Fleiss Multirater Kappa

[DataSet0]

Overall Agreement[a]

		Asymptotic			Asymptotic 95% Confidence Interval	
	Kappa	Standard Error	z	Sig.	Lower Bound	Upper Bound
Overall Agreement	.444	.258	1.721	.085	.428	.461

a. Sample data contains 5 effective subjects and 3 raters.

Agreement on Individual Categories[a]

			Asymptotic			Asymptotic 95% Confidence Interval	
Rating Category	Conditional Probability	Kappa	Standard Error	z	Sig.	Lower Bound	Upper Bound
.00	.400	.444	.258	1.721	.085	.428	.461
1.00	.600	.444	.258	1.721	.085	.428	.461

a. Sample data contains 5 effective subjects and 3 raters.

Table 1. Expert content reasoning

Fleiss Multirater Kappa

Overall Agreement[a]

		Asymptotic			Asymptotic 95% Confidence Interval	
	Kappa	Standard Error	z	Sig.	Lower Bound	Upper Bound
Overall Agreement	.732	.258	2.836	.005	.716	.748

a. Sample data contains 5 effective subjects and 3 raters.

Agreement on Individual Categories[a]

			Asymptotic			Asymptotic 95% Confidence Interval	
Rating Category	Conditional Probability	Kappa	Standard Error	z	Sig.	Lower Bound	Upper Bound
.00	.533	.732	.258	2.836	.005	.716	.748
1.00	.467	.732	.258	2.836	.005	.716	.748

a. Sample data contains 5 effective subjects and 3 raters.

Table 2. Expert content learning strategy

Qualitative techniques often use meaningful information, begin from few or no basic assumptions, and strive to comprehend, elucidate, or characterise events in order to learn, examine what transpires that is suitable for the purpose, and take place in a more natural setting. The experienced lecturers 'responses were transcribed and the emerging themes are as follows: The links between the CLS (think-pair-share) phase and the learning principles phases; the exact content; and discovery, shared activity, thinking, and play fun with GG. The developing themes were scrutinised based on the records of the interview. The response confirmed the lecturers' assessment of the LS with CLS in SEII and GG integration based on the qualitative data acknowledged below.

S/N	QUESTIONS	verbatim Quotes	Themes
1.	What link between the learning principles phases and the cooperative learning strategy with technology?	**R1**.... There's a link here... The phase consists entirely of replicas of the learning principles stages and the cooperative learning technique with technology (one may conclude that there are direct ties between the LS in SEII with CLS& GG integration in particular terms). **R2,** they are quite suited & fit due to the phases' links, if I may summarize the statement in one word and elaborate more. **R3**... yes, there is a connection between the LS that permits learning to take place.	Links between the phases
2.	Do you think that the content is in line with the National collages of education minimum standard curriculum?	**R1**, I trust ***the content is precise***.... **R2**..... *absolutely, it is* ***obtained directly*** *from the content of the Nigerian n*ational collages of education minimum standard curriculum (MATH 224). **R3**..... *certainly, it's* ***quite in line*** *with the content of the n*ational collages of education minimum standard curriculum (MATH 224).	Precise content
3.	Do you think that the activities provided in LS are suitable for developing or improving SEII via CLS and GG integration?	***R1****, sure, why if the opportunity is given to students to use a share activity in discovering and creating a better activity that can resolve their learning difficulties...a.... a..... I think they will appreciate it and can* ***develop their shared activity reasoning capabilities****.* **R2**, certainly, of course, *because the activities can arouse reasoning via playing and fun through the GG icons by using questions to extract meaning out of their activity..... so absolutely.* ***R3****, yes, I believe if you follow the activity and provide a better learning environment, the thinking of the learners can improve*	Shared activity, discovery, play fun (GG) and thinking.

Table 3. Responses from the Experience lecturers' interview about LS in SEII with CLS and GG

Sailin and Mahmor (2018) argued that the qualitative technique was utilised to investigate how students learn from the viewpoints of students and instructors through reflections and critical assessments of the learning process. Assessment is part of education and, to improve the teaching and learning process in schools, the connection between assessment, curriculum, and instruction is critical (Ghazali, 2016) Nevertheless, the experts' feedback was further subjected to Levene's test to compare the equality of variances between pre-test and post-test. The outcomes showed a statistically significant effect at post-test while the pre-test was low-significant at .005 level of significance and the error variance of the dependent variable was equal across groups. Table 4 below shows the result for the Levene's test for equality of variances.

Levene's Test of Equality of Error Variances[a]

Dependent Variable: PRETEST

F	df1	df2	Sig.
8.631	2	38	.001

Levene's Test of Equality of Error Variancesa

Dependent Variable: POSTTEST

F	df1	df2	Sig.
5.156	2	38	.010

Table 4. Levene's test for equality of variances

Table 5 below demonstrates the pre- and post-test analysis of LS with CLS in SEII and GG integration with respect to the variations in mean scores and the requisite objectivities for students' learning engagement. In pre-test, only CLS, the control group passed, with the mean of 40.384 while the experimental group failed with 33.642 and 31.071. The post-test shows that SE variations have increased slightly when compared with the pre-test outcome, with fourteen (14) CLS and GG students representing 44.142 and fourteen (14) GG students representing 41.714 as the experimental group. The control group consists of thirteen (13) CLS students, with 35.846.

Descriptive Statistics

Dependent Variable: PRETEST

STRATEGY	Mean	Std. Deviation	N
CLS and GG	33.6429	5.61053	14
GG	31.0714	5.91562	14
CLS	40.3846	6.17169	13
Total	34.9024	6.96349	41

Descriptive Statistics

Dependent Variable: POSTTEST

STRATEGY	Mean	Std. Deviation	N
CLS and GG	44.1429	5.64129	14
GG	41.7143	5.60808	14
CLS	35.8462	6.71871	13
Total	40.6829	6.80235	41

Table 5. Variations of students' engagement in different strategies for the pre and posttest

The pre-test mean and standard deviation of the three learning strategies were varied and showed that the control group's performance was slightly better than the experimental group's. Similarly, at post-test, the experimental group's performance has improved compared to the control group because of the treatment they received. This further affirms the need for the development of LS with CLS in SEII and GG integration lessons engagement. This means that the groups differ in baseline and ANCOVA can be used to account for the baseline differences by using post-test scores as the dependent variable and pre-test as the covariate. Also, the groups or strategies were randomly assigned and comparing changes between or within groups by interchanging the dependent variable is possible. Thus, the residual is the variance that represents the difference from the pre-test after removing the variation described by the pre-test from the post-test. ANCOVA is made to account for covariates when groups are assigned at random, but not for inadvertent group differences like male and female (Jamieson, 2004). The results below demonstrate how the dependent variable changes as the categorical independent variable changes by using estimated marginal means of pre-test and post-test as shown in Figure 5 and Figure 6, respectively.

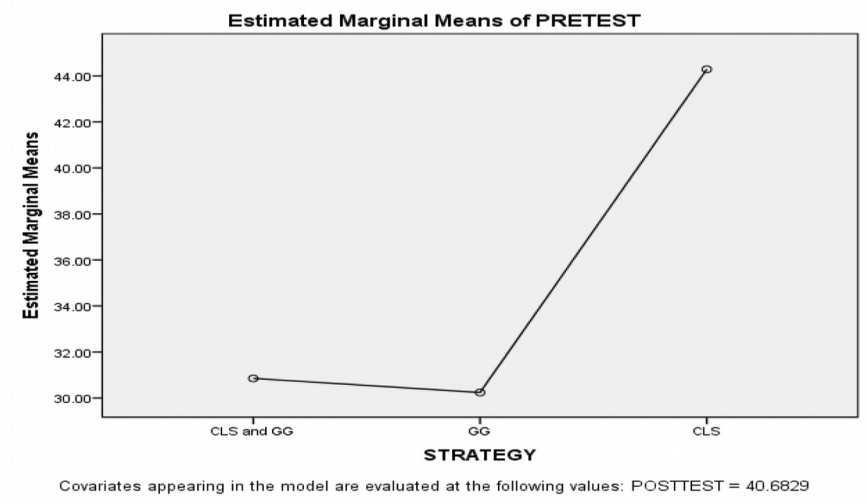


Figure 5. Pre-test estimated marginal means

In Figure 5 above, the covariates appearing in the model are evaluated at post-test 40.682. Controlling the covariate post-test for each strategy implies that effect of the post-test has been statistically removed. From these adjusted means, all the strategies vary.

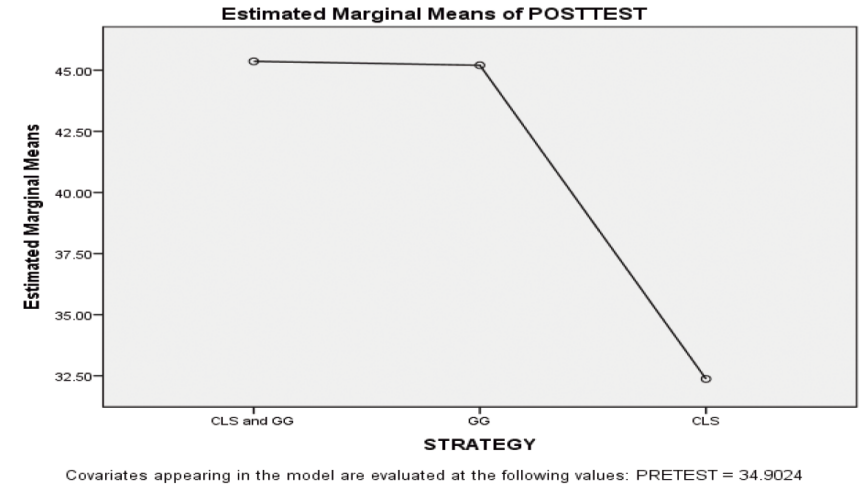


Figure 6. Post-test estimated marginal means

In Figure 6 above, the covariates appearing in the model are evaluated at pre-test 34.902. Controlling the covariate pre-test for each strategy implies that effect of pre-test has been statistically removed. From these adjusted means, the experimental group or explanatory variables, CLS and GG and GG are slightly significant at the post-test while the control group or response variable, CLS, is low and its means that the relationship between the explanatory variables and the response variable is therefore affected at post-test. The outcome of the post-test was vividly signifying the need for the LS by the students when compared with the pre-test.

6. Conclusions

The entire evaluation reveals a favourable response from professionals and students' engagement (SE) in simultaneous equation involving indices (SEII)in the learning strategies through Fleiss multirater Kappa, levenes test, verbatim interview, SE variation means, and the estimated marginal means arising from the pre and post-test of the preliminary study. Only students who were taking Math 224 in junior secondary schools were involved in the study, focusing on SEII. This article makes use of think-pair-share,

technological integration, and the learning principles of the social constructivism ideology. The results showed the need for the LS with CLS and GG integration in learning SEII. The LS with CLS in SEII and GG integration could be appropriate for school algebra, with more research needed to compare its effectiveness to other techniques. For future research, other areas from algebra in three variables and trigonometric ratios and their application may be explored with using technology. Also, students from primary or university levels of education may use similar scenario in their investigation or used different population, gender, and participants locations.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

Abdurrahman, M.S., Abdullah, A.H., & Osman, S. (2020). Developing mathematical thinking among polytechnic students in linear algebra through peer tutoring strategy. *Journal of Advanced Research in Dynamical and Control Systems,* 12(3), 423-434. https://doi.org/10.5373/JARDCS/V12I3/20201210

Aliyu, J., Osman, S., Kumar, J.A., Talib, C.A., & Jambari, H. (2022). Students ' Engagement through Technology and Cooperative Learning : A Systematic Literature Revie. *International Journal of Learning and Development,* 12(3), 23-40. https://doi.org/10.5296/ijld.v12i3.20051

Aliyu, J., Osman, S., Daud, M.F., & Kumar, J.A. (2021). Mathematics teachers' pedagogy through technology: A systematic literature review. *International Journal of Learning, Teaching and Educational Research*, 20(1), 323-341. https://doi.org/10.26803/IJLTER.20.1.18

Alqahtani, M.M., & Powell, A.B. (2017). Mediational activities in a dynamic geometry environment and teachers' specialized content knowledge. *Journal of Mathematical Behavior*, 48(July), 77-94. https://doi.org/10.1016/j.jmathb.2017.08.004

Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *Australian Primary Mathematics Classroom*, 17(1), 9-13.

Berger, J.L., & Karabenick, S.A. (2011). Motivation and students' use of learning strategies: Evidence of unidirectional effects in mathematics classrooms. *Learning and Instruction*, 21(3), 416-428. https://doi.org/10.1016/j.learninstruc.2010.06.002

Bessong, F.E., Ubana, U.A., & Udo, D.E. (2013). Status of the Quality of Teaching and Learning Mathematics in Nigerian Colleges of Education. *Academic Journal of Interdisciplinary Studies*, 2(5), 17-24. https://doi.org/10.5901/ajis.2013.v2n5p17

Chief Examiner's Report (2018). *The West African Examinations Council Chief Examiners' Report*. Available at: https://www.waecgh.org/uploads/examinersReport/

Christenson, S.L., Wylie, C., & Reschly, A.L. (2012). Handbook of Research on Student Engagement. In *Handbook of Research on Student Engagement*. https://doi.org/10.1007/978-1-4614-2018-7

Creswel, J.W. (2014). Research Design. In *Printed in the United States of America Library of Congress Cataloging-in-Publication Data.*

Curry, J. (2016). *a Qualitative Study of Peer Tutoring Developmental Mathematics At The University Level.* Disertation. Kent State University College of Education, Health, and Human Services.

Daoud, R., Starkey, L., Eppel, E., Vo, T.D., & Sylvester, A. (2020). The educational value of internet use in the home for school children: A systematic review of literature. *Journal of Research on Technology in Education*, 0(0), 1-22. https://doi.org/10.1080/15391523.2020.1783402

Denteneer, L., Van Daele, U., Truijen, S., De Hertogh, W., Meirte, J., & Stassijns, G. (2018). Reliability of physical functioning tests in patients with low back pain: A systematic review. *Spine Journal*, 18(1), 190-207. https://doi.org/10.1016/j.spinee.2017.08.257

Effiom (2017). Mathematics Education: A Panacea for Successful Entrepreneurial Skills for Self Reliance and National Development. *Journal of Resourcefulness and Distinction*, 14(1), 1-9.

Etuk, ED., & Bello, D.O. (2015). Challenges and Prospects of Mathematics Education in Nigeria. *Journal of Assertiveness*, 2276–9684, 1-8.

Falotico, R., & Quatto, P. (2015). Fleiss' kappa statistic without paradoxes. *Quality and Quantity*, 49(2), 463-470. https://doi.org/10.1007/s11135-014-0003-1

Festus, A.B. (2013). Activity -Based Learning Strategies in the Mathematics Classrooms. *Journal of Education and Practice*, 4(13), 8-15.

Ghazali, N.H. (2016). A Reliability and Validity of an Instrument to Evaluate the School-Based Assessment System: A Pilot Study. *International Journal of Evaluation and Research in Education (IJERE)*, 5(2), 148. https://doi.org/10.11591/ijere.v5i2.4533

Heaslip, G., Donovan, P., & Cullen, J.G. (2014). Student response systems and learner engagement in large classes. *Active Learning in Higher Education*, 15(1), 11-24. https://doi.org/10.1177/1469787413514648

Hess, A.K.N., & Greer, K. (2016). Designing for engagement: Using the ADDIE model to integrate high-impact practices into an online information literacy course. *Communications in Information Literacy*, 10(2), 264-282. https://doi.org/10.15760/comminfolit.2016.10.2.27

Huei, Y.C. (2015). Student engagement and learning using an Integrated Student-Lecturer Engagement Design Framework. *Proceedings of IEEE International Conference on Teaching, Assessment and Learning for Engineering: Learning for the Future Now, TALE* (79-85). https://doi.org/10.1109/TALE.2014.7062590

Hwang, J., & Taylor, J.C. (2016). Stemming on STEM: A STEM Education Framework for Students with Disabilities. *Journal of Science Education for Students with Disabilities*, 19(1), 39-49. https://doi.org/10.14448/jsesd.09.0003

Imms, W., & Byers, T. (2017). Impact of classroom design on teacher pedagogy and student engagement and performance in mathematics. *Learning Environments Research*, 20(1), 139-152. https://doi.org/10.1007/s10984-016-9210-0

Jamieson, J. (2004). Analysis of covariance (ANCOVA) with difference scores. *International Journal of Psychophysiology*, 52(3), 277-283. https://doi.org/10.1016/j.ijpsycho.2003.12.009

Jega, S.H. (2017). The Effect of Two Modes of Computer Assisted Instruction on Students' Achievement in Simultaneous Linear Equation in Kebbi State. *International Journal of Education and Evaluation,* 3(11), 9-19.

Johari, P.M.A.R.P., & Shahrill, M. (2020). the Common Errors in the Learning of the Simultaneous Equations. *Infinity Journal*, 9(2), 263. https://doi.org/10.22460/infinity.v9i2.p263-274

Li, L. (2013). Cooperative Learning. *Review of Educational Research*, 50(2), 315-342. https://doi.org/10.3102/00346543050002315

Lior, L.N. (2013). Design and Development Models and Processes. *Writing for Interaction*, 21-42. https://doi.org/10.1016/b978-0-12-394813-7.00002-x

Lipovec, A., & Podgoršek Mesarec, M. (2020). Prospective primary teachers' shift in locus of control and pedagogy focus. *Journal of Mathematics Teacher Education*, 0123456789. https://doi.org/10.1007/s10857-020-09463-3

Martin, A.P. (2018). A quantitative framework for the analysis of two-stage exams. *International Journal of Higher Education*, 7(4), 33-54. https://doi.org/10.5430/ijhe.v7n4p33

McCulloch, A.W., Hollebrands, K., Lee, H., Harrison, T., & Mutlu, A. (2018). Factors that influence secondary mathematics teachers' integration of technology in mathematics lessons. *Computers and Education*, 123(April), 26-40. https://doi.org/10.1016/j.compedu.2018.04.008

Mudaly, V., & Fletcher, T. (2019). The effectiveness of geogebra when teaching linear functions using the IPad. *Problems of Education in the 21st Century*, 77(1), 55-81. https://doi.org/10.33225/PEC/19.77.55

Nasiru, H.M., Abdullah, A.H., & Norulhuda, I. (2019). Design and Development of VH-iSTEM Learning Strategy on Geometric Thinking: An Experts' Evaluation. *International Journal of Recent Technology and Engineering*, 8(3S2), 723-732. https://doi.org/10.35940/ijrte.c1230.1083s219

Niemi, H., Niu, S., Vivitsou, M., & Li, B. (2018). Digital storytelling for twenty-first-century competencies with math literacy and student engagement in China and Finland. *Contemporary Educational Technology*, 9(4), 331-353. https://doi.org/10.30935/cet.470999

Nizoloman, O.N. (2013). Relationship between Mathematical Ability and Achievement in Mathematics among Female Secondary School Students in Bayelsa State Nigeria. *Procedia - Social and Behavioral Sciences*, 106, 2230-2240. https://doi.org/10.1016/j.sbspro.2013.12.254

Nordin, N.N.H., Tengah, K.A., Shahrill, M., Tan, A., & Leong, E. (2017). Using Visual Representations As an Alternative in Teaching Simultaneous Equations. *Proceeding of the 3rd International Conference on Education,* 3, 198-204. https://doi.org/10.17501/icedu.2017.3121

Rahi, S. (2017). Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development. *International Journal of Economics & Management Sciences*, 06(02). https://doi.org/10.4172/2162-6359.1000403

Safiya, S. (2021). Perception on Problems and Prospects of Integrating Information and Communication Technology in Basic Science among Primary School Teachers in Zaria LGA, Kaduna State. *Zamfara International Journal of Education The Official Journal of Faculty of Education Federal University Gusau, Zamfara State, Nigeria Maiden Edition,* 1(1), 307-316.

Sailin, S.N., & Mahmor, N.A. (2018). Improving student teachers' digital pedagogy through meaningful learning activities. *Malaysian Journal of Learning and Instruction*, 15(2), 143-173. https://doi.org/10.32890/mjli2018.15.2.6

Saputra, E., & Fahrizal, E. (2019). The Development of Mathematics Teaching Materials through Geogebra Software to Improve Learning Independence. *Malikussaleh Journal of Mathematics Learning (MJML)*, 2(2), 39-44. https://doi.org/10.29103/mjml.v2i2.1860

Saralar, I., Işiksal-Bostan, M., & Akyüz, D. (2018). The evaluation of a pre-service mathematics teacher's TPACK: A case of 3D Shapes with GeoGebra. *International Journal for Technology in Mathematics Education*, 25(2), 3-21. https://doi.org/10.1564/tme_v25.2.01

Shida, N. (2019). *Enhancing Problem Solving in Integral Calculus Through Critical Thinking Learning Strategy Among Polytechnic Students*. Universiti Teknologi Malaysia.

Talib, A., & Kailani, I.B. (2014). Problem Based Learning in Cooperative Situation (PBLCS) and Its Impact on Development of Personal Intelligence. *International Journal of Evaluation and Research in Education (IJERE)*, 3(4), 236-244. https://doi.org/10.11591/ijere.v3i4.6969

Ugboduma, O. (2013). Students' Preference of Method of Solving Simultaneous Equations. *Global Journal of Educational Research*, 11(2), 129-136. https://doi.org/10.4314/gjedr.v11i2.8

Usman, M. (2019). Concept Mapping Instructional Strategy and Senior Secondary Students' Performances and Interest in Algebra in Bauchi State. *Abacus (Mathematics Education Series),* 44(1), 236-243. https://man-nigeria.org.ng/issues/ABA-EDU-2019-30.pdf

Veiga, F.H., Reeve, J., Wentzel, K., & Robu, V. (2014). Assessing students' engagement: A review of instruments with psychometric Qualities. *Envolvimento Dos Alunos Na Escola: Perspetivas Internacionais Da Psicologia e Educação / Students' Engagement in School: International Perspectives of Psychology and Education*, 38-57. http://repositorio.ul.pt/handle/10451/18036

Vveinhardt, J., & Gulbovaitė, E. (2016). Expert Evaluation of Diagnostic Instrument for Personal and Organizational Value Congruence. *Journal of Business Ethics*, 136(3), 481-501. https://doi.org/10.1007/s10551-014-2527-7

Wahab, R.A. (2017). Evaluation by Experts and Designated Users on the Learning Strategy using SketchUp Make for Elevating Visual Spatial Skills and Geometry Thinking / Avaliação de Peritos e Utilizadores Indicados na Estratégia de Aprendizagem Usando o SketchUp Make no Aumento das Competências Visual-Espacial e Pensamento Geométrico. *Boletim de Educação Matemática,* 31(58). https://doi.org/10.1590/1980-4415v31n58a15

Wang, X. (2015). The Literature Review of Algebra Learning: Focusing on the Contributions to Students' Difficulties. *Creative Education*, 06(02), 144-153. https://doi.org/10.4236/ce.2015.62013

Warner, S., & Kaur, A. (2017). The Perceptions of Teachers and Students on a 21 st Century Mathematics Instructional Model. *International Electronic Journal of Mathematics Educatione*, 12(2), 193-215. https://www.iejme.com/article/the-perceptions-of-teachers-and-students-on-a-21st-century-mathematics-instructional-model https://doi.org/10.29333/iejme/609

Zengin, Y., & Tatar, E. (2017). Integrating dynamic mathematics software into cooperative learning environments in mathematics. *Educational Technology and Society*, 20(2).

Zulnaidi, H., Oktavika, E., & Hidayat, R. (2020). Effect of use of GeoGebra on achievement of high school mathematics students. *Education and Information Technologies*, 25(1), 51-72. https://doi.org/10.1007/s10639-019-09899-y

Zulnaidi, H., & Zamri, S. (2017). The effectiveness of the geogebra software: The intermediary role of procedural knowledge on students' conceptual knowledge and their achievement in mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(6). https://doi.org/10.12973/eurasia.2017.01219a

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