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Retention Learning of Students in Machine Language: What can Culturo-Techno-Contextual Approach (CTCA) do?

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Abstract

This study aimed to determine the difference between (a) the retention of information by students taught machine learning using the culturo-techno-contextual approach (CTCA) and the lecture method; (b) the retention of information by male and female students taught machine learning using CTCA; and (c) the interaction effects of gender and the teaching methods on the retention of information by students taught machine learning using CTCA and lecture. Adopted learning ideas include Vygotsky's theory of constructivism, Ausubel's philosophy of meaningful learning, and the philosophical framework of the CTCA. This study employed sequential explanatory mixed methodologies and a quasi-experimental research methodology. A total of 138 learners in senior secondary II participated in the study. The reliability of the Machine Language Achievement Test (MLAT) was determined using the split-half method, which yielded a Spearman-Brown coefficient of 0.80. There is a statistically significant difference in method of teaching [$F(1, 137) = 111.61$; $p<0.05$], which was in favour of the CTCA group (experimental). There is no statistically significant difference in the gender of the students in the experimental group [$F(1, 137) = 0.08$; $p > 0.05$]. The interaction effect of methods and gender is not statistically significant [$F(1, 137) = 1.61$; $p = 0.21$]. We therefore encouraged and suggested that secondary school computer studies teachers should utilise CTCA in order to improve student learning.

Key words: Machine language, Culturo-Techno-Contextual Approach (CTCA), Retention, Difficult concepts, Cultural practices, STEM Education.

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1. Background

The concept of machine language in computer studies new curriculum is an important subject and part of everyday science topics that necessitate a variety of instructional teaching methods to promote comprehension and sustainable living. Consequently, computer studies academia has been concerned with discovering effective techniques or methods for teaching the topic at the secondary school level that can alter students' attitudes about the subject in order to expand students' knowledge and achievement. The curriculum has been criticised for being too diverse and requiring too many calculations; there is a lack of computer studies teachers with 21st-century science teaching skills; and students believe that computer studies is too abstract (Byukusenge, Nsanganwimana, & Tarmo, 2022; Banda, & Nzabahimana, 2022; Onyewuchi, Adewusi, Okebukola, Odekeye, Gbeleyi, & Awaah, 2021; Adewusi, 2021). These are some of the reasons some computer studies concepts are difficult for learners to comprehend.

Students' poor performance in machine language concept examinations demonstrates that they are having difficulty learning, mastering, and applying the teaching and learning materials. Lack of competent and practically oriented computer studies teachers, nonfunctioning computer laboratories, teaching approaches, the absence of instructional materials, the nature of examination questions, the abstract nature of machine language concepts, and the expanded nature of the curriculum, which are the primary causes of learning difficulties, insufficient textbooks, and the nature of examination questions all contribute to the perception of difficulty in the computer studies curriculum. (Adewusi, Usman, & Egbowon, 2022).

Determining the influence of reform teaching on students' information retention is a crucial indicator of its efficacy. If the reform is effective, it is anticipated that the rate at which learners retain new information will increase. Examining the impact of the reform on student performance on standardised tests is one way to address this problem. This method permits the evaluation of information retention and gives context regarding the extent to which learning objectives have been attained (Dahl, Staples, Mayhew, & Rockenbach, 2023). Information retention and academic performance are interrelated measures of reform effectiveness that cannot be examined alone. Rather than focusing solely on student achievement, teachers of STEM subjects can increase student retention by employing culturally relevant teaching approaches (Cohen-Miller & Izekenova, 2022).

The competence of the teacher, the method of instruction, the level of preparation of the students, and other factors all have an impact on how well students retain computer studies topics (Adewusi, Egbowon, Abodunrin, & Rahman, 2021). In a prior study, it was found that teachers' inadequacies for delivering online education, inadequate internet access, inconsistent power supply, and significant infrastructural deficiencies in schools are among the issues affecting learning. In the study, the authors conducted an on-site review of the condition of computer studies laboratories and discovered that a typical laboratory possessed few operational computer systems. The desktops were still using an outdated

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operating system and had insufficient RAM, causing them to operate slowly. Students in the experimental group, who were taught computer studies with prior awareness of instructional objectives, outperformed students in the control group, who were taught without prior knowledge of instructional objectives (Gbeleyi, Awaah, Okebukola, Shabani, & Potokri, 2022). Although there was no statistically significant interaction between gender and teaching technique in relation to the mean achievement of students in computer studies, male students outperformed their female counterparts. Gender and ethnicity were not statistically significant indicators of student performance, according to the findings of the study (Gbeleyi, Awaah, Okebukola, Shabani, & Potokri, 2022).

Why machine language?

Computer studies, and specifically the machine language topic, is a concept that has a favourable impact on both personal and national development. As a result, the subject must be taught by qualified teachers who can direct students towards the intended educational goal. Despite this, there has been a significant fall in student performance in computer studies since its inclusion in external examinations in 2018. Available WASSCE chief examiners' reports from May/June 2018 to 2022 demonstrated students' consistent below-average performance in the subject. The examiner's report on feedback blamed the students' repeated failures on a lack of topic knowledge, poor handwriting, spelling errors, a lack of motivation, noncommitment, and inadequate methodology on the part of the teachers. If the traditional, normal, or conventional lecture method is still used in the classroom of learning, then it could lead to poor academic achievement (Awaah, Oladejo, & Suwadu, 2023).

Moreover, a study conducted on computer studies concepts in the new computer studies curriculum for secondary schools in West Africa in order of perceived difficulty from the most perceived difficult concept to the least perceived difficult concept, which surveyed 1,776 participants from the region because all countries in the region use the same computer studies curriculum for senior school certificate examinations, revealed that machine language was found to be among the most difficult concepts. (Gbeleyi, Awaah, Okebukola, Shabani, & Potokri, 2022).

Sustaining a nation's technological prowess could be significantly impacted by enhancing students' knowledge and interest in computer studies subjects. However, the abstract nature of machine language makes it difficult to teach because there are no physical or conceptual models to assist the students. (Johnson, & Czerniak, 2023). Therefore, it is of the utmost importance that students receive additional assistance in applying their conceptual understanding to a variety of contexts, which includes a focus on the definition of system knowledge in conjunction with examples from various nearby physical components.

Machine language is a crucial concept in computer studies in senior secondary school. According to Adewusi (2021), it is a concept of discipline in artificial intelligence (AI) that deals with computer programming in 0s and 1s. Understanding the concept involves a variety of methods, the most important of which is the learning of binary digits, which is the only language that computing devices understand.

2. Research questions

Following are the research questions to which solutions were sought:

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(1) Will there be a statistically significant difference in information retention between students taught machine language using CTCA and those taught using the lecture method?

(2) Is there a statistically significant difference between the recall of materials by male and female students taught machine language using CTCA?

(3) Is there a statistical interaction between method used and gender in the retention of materials by the CTCA group and the lecture group in machine language?

3. Theoretical and philosophical framework

This study examined Vygotsky's sociocultural theory, Ausubel's theory of meaningful learning, and the philosophical framework of the CTCA.

The sociocultural learning theory of Lev Vygotsky emphasises the significance of social and cultural interactions in the learning process. Vygotsky asserted that learning occurs with the aid of others, thereby contributing to the social aspect of his theory. The more knowledgeable other (MKO) and the zone of proximal development (ZPD) are the two underlying assumptions of Vygotsky's work on collaboration. MKO refers to an individual with superior knowledge or skill in the subject matter (such as a specific task, method, or concept) compared to the learner. (Okebukola, 2019; Adewusi, Usman, & Egbowon, 2022).

According to Ausubel's theory of meaningful learning, an advanced organiser statement that introduces a lesson is designed to evaluate the material to be taught and connect it to previously encountered information in a learner's schema. Ausubel was inspired to present his advanced organiser theory by his desire for students to acquire knowledge in a manner other than rote memorization. Meaningful learning is dynamic, innovative, and long-lasting, but most importantly, it allows students to fully engage in the learning process. Existing cognitive structure provides a framework in which new learning is hierarchically related to a person's existing information or concepts (Okebukola, 2019; Adewusi, Usman, and Egbowon, 202).

CTCA is firmly rooted in culture, technology, and context, as well as their interaction. Relevant philosophies consist of those of Kwame Nkrumah (ethnophilosophy) for culture, Martin Heidegger (technophilosophy) for technology, and Michael Williams (contextualism) for the contextual basis of the CTCA. Ethnophilosophy is the study of indigenous philosophical systems (Okebukola, 2019). Ethnophilosophy is predicated on the notion that a particular culture may have a philosophy that is not applicable and accessible to all cultures and peoples around the world, despite sharing similarities with other cultures.

Adebayo, Oladejo, and Okebukola (2022) found that CTCA had a significant impact, as learners in the experimental group outperformed their counterparts in the control group on both the achievement measure and the attitude towards learning a science concept. It was discovered that CTCA has a substantial effect on the academic achievement of learners when taught with it. They discovered that CTCA had a substantial effect on students' attitudes about learning a concept taught in the class. It was discovered that there is a considerable difference between the CTCA and the traditional technique in terms of students' academic achievement, with the former being significantly more effective.

4. Methodology

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Explanatory sequential mixed methods were used in this research. This study employed a quasi-experimental design (pretest, posttest, non-equivalent group design). We were unable to randomly assign participants to the experimental and control groups at the time of data collection; therefore, an intact class was used. In this study, there were two groups: an experimental group and a control group, each of which was composed of an intact class. Our study's interview component sought computer studies students' perspectives on CTCA utilisation. Three students were selected at random and granted permission to be interviewed.

4.1 Participants

The population of this study consists of students enrolled in computer studies classes at senior secondary schools in Lagos State Education District II, Lagos State, Nigeria. There are approximately 200 public and private senior secondary schools in state education district II.

Two public schools in education district II with roughly comparable computer studies teacher credentials, school amenities, and student populations were selected via random sampling. A hundred and thirty-seven students in senior secondary school II (SS II) (equivalent to 11th grade in the American system) participated in the study. The experimental (CTCA) group consisted of 69 students, while the control (lecture) group consisted of 68.

The SS II students were chosen for the study because they have spent one school session (first to third term) learning computer studies contents, processes, and the ethics of science, and have acquired some prerequisites. However, they have not been taught machine language, which was chosen for the study at the time it was conducted.

4.2 Instrumentation

The machine language achievement test (MLAT) was administered as a pre-test and post-test to experimental and control groups. This instrument contained both A and B parts. Section A was designed to collect demographic information about the students, while Section B consisted of 30 multiple-choice questions with four possible answers (A–D). Four weeks after the post-test, the instrument was administered again to assess the students' retention. The machine language interview guide (MLIG) was utilised for the collection of qualitative.

4.3 Validity and Reliability of the Instruments

Experts in the study's field carried out the validation of the instrument's content. The experts were asked to assess the compatibility of the items with the research questions and rating scale. In the end, the study's specialists approved of the tool. To determine its reliability, it was administered to 43 students who were not participating in the study, and IBM-SPSS version 23 was used to analyse the resulting data. A Spearman-Brown coefficient value of 0.80 was determined using a split-half reliability test to determine the instrument's coefficient value.

4.4 Procedure

In the lesson plan, the objectives for the four-week lessons were clearly specified. Both experimental and control groups were taught according to the indicated learning objectives below.

Week 1

Objectives. At the end of the lesson, students should be able to:

1. List the functions of the central processing unit.

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2. Explain the functions of the central processing unit.

Week 2

Objectives. At the end of the lesson, students should be able to:

1. Understand low- and high-level languages;
2. Enumerate machine language converters.

Week 3

Objectives. At the end of the lesson, students should be able to:

1. Explain how instructions are coded as patterns.
2. Explain how the computer distinguishes between instructions and data.
3. Understand memory locations.

Week 4

Objectives. At the end of the lesson, students should be able to:
1. Understand the machine-language instruction cycle.
2. Explain the machine-language instruction cycle.

The experimental group received the CTC approach. The lesson was taught in 4 weeks, following the five steps of implementing CTCA as follows:

4.5 Presentation of Lessons

Step 1.

Prior to the session, students were instructed to

1. a) Consult their parents, use their mobile phones or Internet-enabled devices to explore the web for relevant resources, and view YouTube videos on the topic of "running machine language programmes."

2. b) Consider cultural behaviours and beliefs related to the topic.

Step 2.

1. a) At the beginning of the lesson, the students were welcomed and divided into mixed-ability and mixed-gender groups.

2. b) Each group was given 10 minutes to discuss the assignment from the previous class and select a leader to present the summary to the whole class.

3. c) The group leaders summarised the 10-minute discussion they had on the topic within their groups.

Step 3

The instructor then taught the idea of "running machine language programmes" using examples from Nigerian culture.

Step 4

Contextual examples were shown, stressing some of the findings from the student presentations, and the issue was further explained by linking it to everyday activities. The teacher clarified any misconceptions in the students' presentations.

Step 5

At the conclusion of the class, we provided a 320-word summary of the lesson via the WhatsApp group we made for all the students.

These procedures were also followed for weeks 2 through 4.

5. Indigenous (cultural) knowledge related to the concept of machine language

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The experimental (CTCA) group was taught some of the following indigenous (cultural) knowledge connected to the concept of machine language:

Case Study 1

Traditional Clothes Weaving: This is the process where designs and patterns are made on the Aso-Oke while the cloth is being woven. This is called patterning. After this, the actual weaving starts. The rolled cotton will be neatly inserted into the striker through the extenders (instructions are fetched from RAM). The weaver will tie Iro (the filler) to his seat (the register). There are two or more holes on the staff in which a small peg is tagged. On the upper hand of the Omu (Decode), there is an Okeke (wheel or axle) for pulling the Omu up and down (this is likened to an ALU).

Case Study 2

African Food Recipe: Using a food recipe as an example, the opcode might be chop or mix. In the analogy of a recipe, the thing that the opcode is acting upon is an ingredient (such as an onion). So the opcode chop could act on the operand onion. If the operand refers to a place in memory, this could be seen as the chopping board. The operand (data) of the onion could be in the memory location of the chopping board. The instruction could be to chop the onion on the chopping board.

6. Results

Upon completion of treatment administration, both the experimental and control groups were administered a post-treatment achievement test. Four weeks after the posttest, a retention test was also conducted. The gathered data were analysed using IBM SPSS version 23.

Research Question 1: Will there be a statistically significant difference in the retention of information by students taught machine language using CTCA and those taught using the lecture method?

Table 1.2 shows the mean and standard deviation of the retention test scores of the two groups. The experimental group (CTCA) had a mean score of 21.55 with a standard deviation of 4.00. While the control group had a mean score of 19.75 with a standard deviation of 4.02.

Table 1.2. Mean and Standard Deviation of Retention Test Scores of the Two Groups

Training method	Mean	N	Std. Deviation
CTCA	21.55	69	4.00
Control	19.75	68	4.02
Total	20.66	137	4.10

Table 1.3 indicates that Levene's test of variance equality was insignificant ($p > 0.05$). This indicates that the data variances are not significantly different from those of the normal population, indicating that the data passed the parametric assumption tests and are thus suitable for parametric analysis.

Table 1.3: Levene's Test of Equality of Error Variances

F	df1	df2	Sig.
.000	1	135	.996

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + Retention Test + Training Method

As shown in Table 1.4, the results of a one-way ANOVA with teaching method as the independent variable, retention as the dependent variable, and post-test as the covariate indicate that there is a

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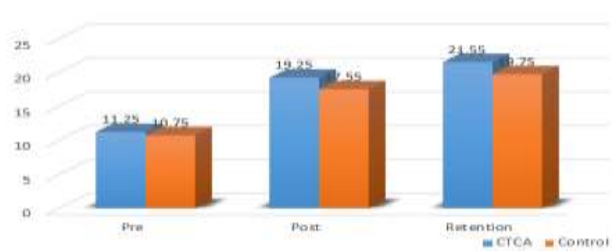
statistically significant difference in teaching method [$F(1,137) = 111.61$; $p < 0.05$]. This indicates that there is a statistically significant difference between the experimental and control groups' teaching methods.

Table 1.4. ANOVA Summary Table of Differences in the Retention of the Two Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	114.76	2	57.38	3.55	.03
Intercept	1401.18	1	1401.18	86.60	.00
Retention Test	3.70	1	3.70	.23	.63
Training Method	111.61	1	111.61	6.90	.01
Error	2168.12	134	16.18		
Total	60742.00	137			
Corrected Total	2282.88	136			

a. R Squared = .050 (Adjusted R Squared = .036)

Figure 1 displays the entry-level mean scores of students in the experimental (CTCA) and control groups. The mean scores for pre-achievement were comparable (CTCA = 11.25 and lecture = 10.75). After the treatment was implemented, the mean scores of students in the experimental group on post-achievement tests increased, as did the mean scores of students in the control group (CTCA = 19.25 and lecture = 17.75). After 4 weeks, when a post-achievement test was administered,



students in the CTCA group retained more information than those in the control group (CTCA = 21.55 and lecture = 19.9). The fact that the mean of the CTCA group is higher than that of the lecture group demonstrates that the CTCA group outperformed the lecture group.

Figure 1. Mean scores of CTCA and lecture groups in achievement and retention.

Research Question 2: Is there any statistical difference in the retention of information by male and female students taught machine language through CTCA?

Table 1.5. Mean and Standard Deviation of Retention Test Scores of Male and Female Students Taught using CTCA

Sex	Mean	Std. Deviation	N
MALE	20.75	4.13	61
FEMALE	20.58	4.09	76
Total	20.66	4.10	137

Levene's test of equality of variances was found to be insignificant ($p > 0.05$). This indicates that the variance data are not significantly different from the normal population, indicating that the data passed the parametric assumption tests and are thus suitable for parametric analysis. As shown in Table 1.6, the results of a one-way ANOVA with sex as the independent variable, retention as the dependent variable, and post-test as the covariate indicate that there is no statistically significant difference between the genders of the students [$F(1, 137) = 0.08$; $p > 0.05$]. This indicates that there is no statistically significant difference between male and female students.

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Table 1.6. ANOVA Summary Table of Difference in the Retention of Male and Female Students Taught using CTCA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.45	2	2.23	.13	.88
Intercept	1388.81	1	1388.81	81.68	.00
Posttest Achievement Score	3.41	1	3.41	.20	.66
Sex	1.30	1	1.30	.08	.78
Error	2278.43	134	17.00		
Total	60742.00	137			
Corrected Total	2282.88	136			

a. R Squared = .002 (Adjusted R Squared = -.013)

Research Question 3: Is there a statistical interaction between gender and method of teaching on the retention of information by students taught machine language using CTCA and the lecture method?

Levene's test of variance equality was insignificant (p >.05). This indicates that the data variances are similar to those of a normal population, indicating that the data passed the parametric assumption tests and are thus suitable for parametric analysis. As shown in Table 1.7, the interaction effect of method and gender is not statistically significant based on the results of a two-way ANOVA [F (1, 137) = 1.61; p = 0.25]. This indicates that the interaction between teaching method and gender of students, whether male or female, has no effect on the retention rate of machine language students.

Table 1.7. ANOVA Summary Table of Difference in the Retention of Male and Female Students Taught using CTCA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	142.70	4	35.68	2.20	.07
Intercept	1424.49	1	1424.49	87.86	.00
Retention Test Score	6.44	1	6.44	.40	.53
Training Method	99.55	1	99.55	6.14	.01
Sex	2.03	1	2.03	.13	.72
Training Method * Sex	26.05	1	26.05	1.61	.21
Error	2140.12	132	16.21		
Total	60742.00	137			
Corrected Total	2282.88	136			

a. R Squared = .063 (Adjusted R Squared = .034)

Unedited responses from the students

Student, CTCA, female: This is incredibly interesting because it has never been done before: can we develop computer understanding and knowledge based on our DNA-based familial relationships? In my own family, I have close relationships; however, I may not have close relationships with others. This helps me comprehend the role of interpreters and translators in computer programming.

Student, CTCA, male: I appreciated learning machine language when it was relevant to our traditional knowledge of languages. As humans, we may communicate with dogs by calling them by different names and requesting that they perform various tasks. So computer instructions are comparable to this, which is interesting.

Student, CTCA, male: I cannot imagine that a topic such as machine language used to teach programming can be compared to a chopping board used to cut 'ewedu' at home. This is mind-boggling to me!

7. Discussion

According to the findings of the first research question, there was a statistically significant difference between the retention rates of students taught machine language via CTCA and those taught via the lecture method.

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This substantial difference favoured the experimental group that was taught machine language using CTCA. The average score of the CTCA group was higher than that of the lecture group (the control group). This indicated that the CTCA group performed better than the lecture group.

In addition, the CTCA group performed better than the lecture group because the CTCA method was more comprehensive. CTCA's use of Vygotsky scaffolding enabled students to receive precisely the right amount of support at precisely the right time. With the assistance of a more experienced teacher and their peers, the students were able to complete the activities, bringing them one step closer to a complete understanding of the subject matter. This is what Vygotsky meant when he discussed students learning from an expert (MKO) and reaching their "zone of proximal development" (ZPD) (Okebukola, 2019; 2020).

We hypothesised that the learning opportunities provided by CTCA could be a contributing factor in the experimental group's success. The students were given advance notice of the material to be covered, and they had numerous opportunities to work together during the various group exercises. CTCA also suggests students use online resources to research the topic so they can be prepared. Using cutting-edge equipment and tried-and-true teaching methods together has been shown to improve science education by a lot (Ani, Ulbrich, Dana-Picard, Cvjetianin, Petrovi, Lavicza, & Marii, 2022; Adewusi, 2021). The CTCA group may have also outperformed the other group due to the teaching method's incorporation of items from the school environment and within the learners' grasp of the subject, making it easier for students to comprehend.

The students in the CTCA group were lectured using indigenous knowledge; for many of them, this was their first exposure to this type of information. Many of them became interested in this as they listened to the diverse knowledge that the various group leaders shared during class presentations. The instructor later imparted additional indigenous knowledge and dispelled any myths the students may have acquired. This is not typical of the other group, and it was one of the factors contributing to the disparity (Okebukola, 2019; 2020).

The lecture group lacked scaffolding; the instructor entered the classroom, gave the students instructions, and then left. They did not receive the same exposure as the CTCA group, and it was not expected that they would outperform the CTCA group, which was bolstered by a variety of techniques. In the CTCA group, the teacher acted as a facilitator as students presented to their partner what they had learned from their interaction with an elderly person regarding the indigenous meaning of the concept, what they had observed on YouTube, and what they had learned from their peers in their own groups (Okebukola, 2019; Adewusi, Egbowon, Abodunrin, & Rahman, 2021).

There were no statistically significant gender differences among students who were taught machine language using the CTCA from the second research question. This demonstrates that gender equality was maintained within the group, as male and female students were given an equal playing field. Furthermore, it suggests that neither gender was considered superior to the other. This research has implications for achieving Sustainable Development Goal (SDG) number 10, which aims to reduce racial inequality (Gbeleyi et al., 2020).

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This outcome is encouraging and ought to serve as a wake-up call to other female students who have a fear of science because their family members or teachers have discouraged them. This result should also encourage parents to encourage their daughters to participate in science and guarantee a positive experience. This indicates that a large number of women are interested in science but have no one to support them. In the past, the perception that science was exclusively for men discouraged many women from pursuing a career in it. This study's findings also indicate that there is no science course in which females cannot perform better; all they need is encouragement to accept the challenge (Okebukola, 2019; Gbeleyi et al., 2020).

The third research question is whether there is a statistically significant interaction between gender and teaching methods among the study's students. Using the teaching methods employed by the study's students, the retention of students is unaffected by gender, regardless of whether the student is male or female. There is no effect of gender on student retention, regardless of whether the student is male or female. This result also demonstrated that the intervention had the same effect on both male and female students. Nevertheless, this suggests that CTCA appears to contain the necessary components to improve male and female classroom learning outcomes. This indicates that the CTCA provided students of all genders with equal opportunities. This is very encouraging (Okebukola, 2019; 2020).

8. Conclusion and Recommendations

A significant contribution to the literature on science education, the study employed a culturally responsive science pedagogy approach. The achievement of success in measuring the usefulness of CTCA in enhancing the retention of senior secondary school students by overcoming barriers to learning machine language contributes to existing teaching methods that facilitate students' understanding of the topic, particularly in Africa.

Therefore, we suggest that:

1. In order to facilitate students' meaningful learning, computer studies teachers in secondary schools could use CTCA as a teaching method, particularly in societies with a diverse cultural makeup.

2. Based on the findings of this and other studies, school administrators and owners should encourage teachers to use accessible technology and local knowledge examples within students' reach to make curriculum content easier to understand. This will increase learning interest and information retention among the students.

3. The curriculum planners should think about suggesting to school science teachers that they use teaching methods and technologies that are sensitive to culture and context. They should also think about ways for local knowledge to be added to students' textbooks.

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