Research Article

Computer-aided Instruction as a key to sustain continuous teaching and learning during the COVID-19 pandemic in Kano State Public Universities

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Abstract:— Conventional educational systems were affected by the COVID-19 pandemic all over the world, including public universities in Kano State, where students had to sit through extended periods of academic inactivity. This disruption made clear the necessity for permanent, alternate teaching strategies to guarantee ongoing instruction in times of emergency. This study examines the efficacy of the Computer Aided Instruction (CAI) approach in addressing this issue and evaluates its capacity to maintain continuous learning both during and after the pandemic. The study employed an experimental research design to assess CAI's effect on students' learning outcomes. They were using Morgan's sample size determination technique. A sample of 360 students was selected from a population of 5,000 enrolled in three public universities in Kano State using Morgan's sample size determination technique. Two groups of students were randomly assigned to each group: one for experimentation using CAI to deliver teaching, and the other for control using conventional techniques. Assessments of the students' performance were done both before and after the test. The data obtained was analyzed using SPSS, which included independent-sampled t-tests and descriptive statistics. The findings revealed a noteworthy enhancement in the experimental group's academic performance relative to the control group ($p < 0.05$), indicating the efficacy of CAI in fostering ongoing learning. These results highlight how important CAI is to preserving academic advancement in the face of interruptions. To improve students' learning resilience in the event of future calamities, the study suggests including CAI in university curricula.

Keywords—Computer Aided Instruction (CAI), Continuous learning, COVID-19 pandemic, Public universities, Experimental design, Sustainable education

1. Introduction

Millions of students and teachers worldwide were impacted by massive disruptions to the global education system brought about by the COVID-19 pandemic. Thousands of students' academic progress stopped when public universities in Nigeria, particularly in Kano State, were forced to close [1]. Restrictions on physical gatherings render conventional in-person teaching methods unworkable, forcing institutions to consider ways to maintain learning continuity. This disturbance questioned the efficacy of conventional teaching strategies and highlighted the pressing need for flexible, alternate educational strategies that could continue learning in an emergency. The Computer-Aided Instruction (CAI) approach is one such substitute that has been demonstrated to improve learning using technology-based tools and resources. By including multimedia components such as text, video, and interactive simulations, CAI keeps students engaged while enabling autonomous learning [2], [3]. Research indicates that by accommodating various learning preferences and offering prompt feedback, CAI can considerably enhance students' learning results [4]. This approach becomes especially important during emergencies such as the COVID-19 epidemic when access to conventional classes is restricted. With the pandemic's issues in mind and CAI's demonstrated efficacy in other contexts, this research endeavor aims to explore CAI's potential as a long-term approach to continuous learning at the Kano State Public Colleges. This study compared the efficacy of CAI with conventional teaching approaches in improving student performance using an experimental research methodology. The findings will shed light on whether CAI may be an effective long-term option for preserving academic advancement in public universities, both during and after emergencies. The present study adds to the increasing corpus of scholarly work on educational technology and its function in ameliorating the effects of worldwide disruptions on tertiary education [5].

1.1 Statement of the problem
Nigeria's educational system has been severely harmed by the COVID-19 pandemic, as has been the case worldwide. Kano forced public higher education institutions to suspend classes

for protracted periods, which seriously interfered with students' ability to learn. Due to the pandemic, conventional face-to-face teaching methods that depend on physical classrooms were insufficient, depriving pupils of high-quality education for several months [5]. This protracted disruption sparked questions regarding the lasting impact on students' performance and overall educational results as well as the viability of conventional teaching approaches during times of crisis. Although online learning platforms gained popularity during the pandemic, infrastructure constraints and staff and student training deficiencies prevented many public colleges in Kano State from using them completely. CAI or computer-assisted instruction offers a possible remedy for this gap. Research has demonstrated that CAI provides engaging and adaptable learning opportunities, which are essential for maintaining school continuity, especially during catastrophes [6]. Still, not enough studies have been carried out on the effectiveness of CAI as a long-term fix in Kano State's public colleges.

This study seeks to fill this knowledge gap by examining the efficacy of CAI as a long-term teaching strategy for ongoing learning both during and after the COVID-19 epidemic. In particular, this study assessed the impact of CAI on student learning outcomes by comparing it with conventional teaching approaches. Our understanding of whether CAI can improve learning resilience and provide a workable substitute for conventional approaches in the event of future disruptions will be greatly enhanced by the results.

1.2 Aim and Objectives

The main purpose of the is to evaluate computer-aided instruction as a means of maintaining ongoing instruction and learning in Kano State public universities during the COVID-19 pandemic period. More precisely, the study aims to:

1. Evaluate the effect of computer-aided instruction (CAI) on student learning outcomes in public universities in Kano State during the COVID-19 pandemic period, employing experimental research design to compare the performance of students exposed to CAI with those taught through conventional methods.
2. Assess the effectiveness of computer-aided instruction (CAI) as a sustainable teaching method for continuous learning during emergencies by analyzing pre-and post-test data from students in both the experimental (CAI) and control (conventional) groups.
3. Determine the extent to which Computer Aided Instruction (CAI) can be integrated into the regular curriculum of Kano State public universities, based on the analysis of student performance using SPSS and the results from the experimental study.

1.3 Research Questions

The research questions were established under the previously specified research objectives:

1. What is the impact of computer-aided instruction (CAI) on student learning outcomes compared to conventional teaching methods in public universities in Kano State during the COVID-19 pandemic?

2. How effective is Computer Aided Instruction (CAI) in sustaining continuous learning during emergencies, as reflected in student performance in Kano State public universities?
3. Can computer-aided instruction (CAI) be successfully integrated into the regular curriculum of public universities in Kano State, based on the comparative analysis of student performance?

1.4 Research Hypotheses

In line with the above-stated research questions, the following research hypotheses were tested at a 0.05 confidence level:

H_{01}: There is no significant difference in student learning outcomes between those who receive instruction via CAI and those taught through conventional methods.

H_{02}: Computer Aided Instruction (CAI) is not an effective method for sustaining continuous learning during emergencies.

H_{03}: Computer Aided Instruction (CAI) cannot be effectively integrated into the regular curriculum of public universities in Kano State.

2. Related Work

The COVID-19 pandemic has underscored the critical need to adopt alternative pedagogical approaches to ensure the continuity of education during disruptions. Among these, computer-aided instruction (CAI) stands out as a valuable method for integrating multimedia tools such as interactive simulations, video lessons, and quizzes into the educational experience. By leveraging technology, CAI accommodates diverse learning styles and allows students to learn at their own pace, enhancing both engagement and academic outcomes [6]. This adaptability is especially beneficial in times of crisis, such as a pandemic, when traditional in-person teaching may be unfeasible. Extensive research in higher education demonstrates CAI's effectiveness in improving academic achievement. For instance, [7] found that students exposed to CAI consistently outperformed their peers taught using conventional methods, achieving higher test scores and demonstrating a better grasp of course material. Additionally, a study by [8] highlighted that CAI fosters improved knowledge retention and critical thinking skills, suggesting that CAI not only supports the immediate learning process but also contributes to lasting academic benefits.

Despite these advantages, implementing CAI presents significant challenges, particularly in regions with limited technological infrastructure, such as Kano State, Nigeria. Many public universities in Kano face substantial barriers to adopting CAI, including limited access to reliable internet, insufficient technological resources, and a shortage of trained personnel capable of effectively integrating CAI into their teaching practices [7]. These limitations restrict the full potential of CAI and highlight the need for targeted investment in technology and training to bridge the digital divide. Moreover, research on the long-term sustainability of CAI in resource-constrained environments remains scarce. Understanding CAI's effectiveness and adaptability in such

contexts, particularly over extended periods, is essential to developing strategies that will support uninterrupted learning during both regular and emergency conditions.

This study seeks to address these gaps by examining the impact and efficacy of CAI in Kano State's public universities throughout the COVID-19 pandemic. By comparing CAI with traditional teaching methods, this research will provide valuable insights into CAI's ability to sustain educational continuity during crises and assess its potential for long-term integration in resource-limited settings. Findings from this study could inform policy decisions and resource allocation, ultimately supporting the broader adoption of CAI to enhance resilience in higher education.

2.1 Research Framework

A research framework serves as a crucial blueprint for guiding a study, illustrating the relationships between various variables while establishing the theoretical foundation underlying the research. In this context, Figure 1 presents the research framework for the study titled "Computer-Aided Instruction as a Key to Sustaining Continuous Learning during the COVID-19 Pandemic in Kano State Public Universities, Nigeria." This framework encapsulates the core components of the research, including the independent variable Computer-Aided Instruction (CAI) and the dependent variables related to student learning outcomes, such as engagement, knowledge retention, and overall satisfaction. The framework is grounded in established educational theories that highlight the importance of technology in enhancing learning experiences, particularly during crises like the COVID-19 pandemic.

By illustrating how CAI influences various aspects of learning, the framework provides a visual representation of the pathways through which technology can sustain educational continuity. It also identifies potential moderating factors, such as student attitudes toward technology and the adequacy of technical support, which may impact the effectiveness of CAI. Overall, this research framework not only clarifies the study's objectives but also situates it within the broader context of educational resilience and innovation during challenging times.
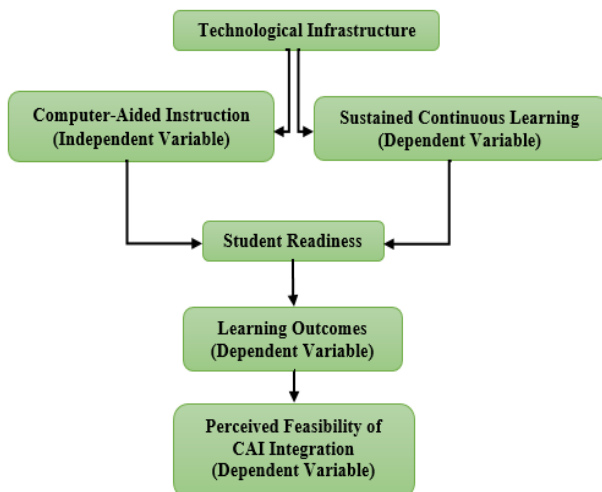

Figure 1. Research Framework

This research framework summarizes the expected relationships between CAI (the independent variable) and key learning outcomes, Sustained Continuous Learning, and Perceived Feasibility of Integration (dependent variables). It also accounts for moderating factors, such as infrastructure and readiness, providing a clear structure that guides data collection, analysis, and interpretation. The theoretical foundation rooted in Constructivist Learning Theory supports the idea that CAI is an effective tool for sustaining learning during crises and in regular academic contexts (see Figure 1).

2.2 Research Gap

Although a substantial amount of research has shown that computer-aided instruction (CAI) improves student learning outcomes, most of these studies have been carried out in developed nations with sophisticated technological infrastructures [5], [6]. In contrast, few researches have been conducted regarding the viability and efficacy of CAI in developing nations like Nigeria, especially in public universities in Kano State, where access to technological resources is frequently restricted. Furthermore, most of the literature published to date has concentrated on the general advantages of CAI under ideal circumstances, paying little attention to its function in preserving educational continuity during emergencies like the COVID-19 pandemic [1].

Furthermore, although CAI has been investigated as an additional teaching tool, few researchers have carefully compared its efficacy with conventional techniques in contexts with limited resources during emergencies. Empirical studies are required to determine whether CAI can be used in public universities as a long-term, viable solution for continuous learning, especially in times of disruption such as the pandemic. By investigating the possibility of using CAI to guarantee continuous learning in public institutions in Kano State during the COVID-19 pandemic period, this research seeks to close these gaps. This study compared the efficacy of CAI with conventional techniques and determined whether it can be used as a viable, long-term teaching tool in classrooms with limited resources. To create plans for potential disruptions in education in the future, legislators and educators will find this to be quite perceptive.

2.3 Impact of Computer-Aided Instruction (CAI) on Student Learning Outcomes

Numerous scholarly investigations have underscored the capacity of computer-aided instruction (CAI) to augment student learning results in various educational contexts. Multimedia resources, including animations, simulations, and films, can be integrated with CAI to enhance the dynamic and captivating nature of learning [5]. By giving students more influence over the learning process, CAI has been demonstrated in higher education to improve the retention and understanding of complicated concepts [6]. There is a knowledge vacuum regarding its efficacy in resource-constrained settings, such as Kano State public universities, as the majority of these studies are conducted in highly developed technological environments.

2.4 Effectiveness of CAI for Continuous Learning During Emergencies

The global disruption of conventional learning systems caused by the COVID-19 pandemic indicates the need for alternate teaching approaches. During this time, CAI became an essential tool for maintaining continuous learning, particularly when in-person instruction was no longer practical (8). Studies show that by enabling students to participate in self-paced learning and have remote access to instructional resources, CAI can be successful in delivering continuous education [9]. However, the usefulness of CAI in emergencies is still poorly understood, especially in developing nations with weak technological infrastructure, such as Nigerian public colleges.

2.5 Integration of CAI into the Regular Curriculum

Seamless integration of CAI into educational institutions' normal curricula is necessary for sustainability. Research indicates that CAI is most successful when it offers a hybrid approach to education and works best when it supplements conventional methods rather than replacing them [10]. However, there are obstacles to incorporating CAI into the curriculum at Kano State's public universities, such as limited technological access, shortage of qualified staff, and inadequate infrastructure. Several obstacles must be overcome to make CAI a scalable and long-lasting solution for continuous learning.

3. Research Theory

Constructivist learning theory, which was originally developed by academics such as Jean Piaget and Lev Vygotsky, offers a solid theoretical framework for comprehending how well computer-aided instruction (CAI) works to maintain continuous learning during crises such as the COVID-19 pandemic period. With this approach, students actively construct their knowledge and understanding of the world through reflection and hands-on experience [11], [12]. Because CAI platforms frequently offer interactive, student-centered learning environments in which learners can engage with multimedia information, simulations, and quizzes, the constructivist approach is extremely applicable in the context of CAI. Unlike conventional teaching approaches, which require students to passively absorb information, this approach enables them to construct their knowledge actively [13]. Because many platforms feature collaboration tools such as discussion boards, peer assessments, and group projects that can support social learning, even in a virtual context, the authors emphasize that social interaction in learning also resonates with CAI. When face-to-face instruction is disrupted by emergencies such as the COVID-19 epidemic, CAI can offer a dynamic learning environment that upholds the constructivist principle of learning-by-doing. Through interactive digital interactions, students can develop knowledge through self-regulated learning at their own pace [13]. According to this hypothesis, students are more likely to retain knowledge, exercise critical thinking, and perform better academically when they have control over their learning process. For these reasons, CAI offers a potentially long-lasting option for continuous learning in times of crisis.

4. Experimental Method/Procedure/Design

A quasi-experimental design was employed in this research [14], utilizing both pre- and post-tests alongside a structured questionnaire to collect data. This approach enabled a robust comparison of learning outcomes between students engaged in computer-aided education (CAI) and those receiving conventional classroom instruction. The timing of the study during the COVID-19 pandemic provided a unique opportunity to assess how effectively CAI facilitated learning under challenging circumstances.

Using Krejcie and Morgan's sample size determination method, a total of 360 undergraduate students from three public universities in Kano State were selected from a larger population of over fifteen thousand students across various departments. The sample was divided into two distinct groups: the control group, which followed conventional teaching methods, and the experimental group, which utilized CAI. Initially, a pre-test was administered to both groups to gauge their baseline knowledge of the subject matter. Following the instructional period, a post-test was conducted using the same assessment to measure knowledge gains. This design allowed for a clear evaluation of CAI's impact on student learning outcomes through a comparison of pre-and post-test scores.

In addition to quantitative measures, qualitative data were gathered through a structured questionnaire that explored students' perceptions of CAI, their technological experiences, engagement levels, and overall satisfaction with the learning process. This qualitative data is essential for understanding the scalability and sustainability of CAI in future educational contexts, especially during emergencies. Statistical analysis was performed using SPSS, employing independent t-tests and descriptive statistics to analyze the performance differences between the two groups. This comprehensive approach not only assessed the efficacy of CAI but also provided valuable insights into students' experiences during the learning process.

5. Results and Discussion

Research Question 1: What is the impact of CAI on student learning outcomes compared to conventional teaching methods?

Table 1: Learning Outcomes

Group	Mean	Std. Deviation	t	Df	p-value
CAI Group (n = 149)	78.24	6.85	3.45	295	0.001
Conventional Group (n = 148)	72.58	7.12			

Source: Fieldwork

Interpretation:
The CAI group's mean learning outcome score was higher (M = 72.58, SD = 7.12) than the conventional group (M =

78.24, SD = 6.85). The null hypothesis was rejected because the t-test results demonstrated a statistically significant difference in learning outcomes between the two groups (t (295) = 3.45, p = 0.001). This suggests that learners utilizing CAI outperformed those using conventional instructional techniques. This was in line with research by [16], which showed that incorporating technology such as CAI improves learning outcomes by giving students flexible and engaging ways to connect with the material. The results of the present study support these findings. Analogous research has demonstrated that applying CAI enhances memory and problem-solving abilities [17].

Research Question 2: How effective is CAI in sustaining continuous learning during emergencies such as the COVID-19 pandemic period?

Table 2: Sustained Continuous Learning

Group	Mean	Std. Deviation	t	df	p-value
CAI Effectiveness	4.05	0.82	18.67	148	0.000

Source: Fieldwork

Interpretation:
The effectiveness of CAI has a mean score (M = 4.05, SD = 0.82) that is considerably higher than the neutral value of 3 (t (148) = 18.67, p = 0.000), according to the one-sample t-test. This suggests that during the COVID-19 pandemic, most students thought that CAI helped maintain learning. Thus, we rejected the null hypothesis. These results are corroborated by a study conducted in [18], which discovered that computer-assisted and Internet approaches made it possible to implement educational programs amid the COVID-19 pandemic. Access to learning resources and flexibility are crucial amid unanticipated disruptions, such as pandemics, which is why CAI offers both.

Research Question 3: Can CAI be integrated into the regular curriculum of public universities in Kano State?
Hypothesis:

Table 3: The integration of CAI into the curriculum

Variable	Chi-Square	Df	p-value
Perceived effectiveness Feasibility of integration	15.67	4	0.005

Source: Fieldwork

Interpretation:
According to the Chi-Square Test of Independence (χ^2 (4) = 15.67, p = 0.005), the feasibility of incorporating CAI into the regular curriculum and students' impressions of its usefulness. This indicates that students were more likely to favor CAI inclusion in the university's normal curriculum if they thought it was effective. We reject the null hypothesis. Similarly, [19] found that by encouraging student participation and providing teachers with more resources, incorporating CAI into conventional educational environments improved the quality of learning. According to

their research, CAI has the potential to be an important curriculum component given the right framework.

Discussion of Findings
This study examined how computer-aided instruction (CAI) influenced student learning outcomes, how well it maintained learning during emergencies, and whether it could be incorporated into the normal curriculum of Kano State's public universities. These results fill the research gaps noted in this study and complement previous knowledge.

Hypothesis 1: There is no significant difference in students' learning outcomes between those who receive instruction via CAI and those taught through conventional methods.

The findings of this study revealed that students in the Computer-Assisted Instruction (CAI) group scored significantly higher on the post-test than those who received standard teaching, indicating that CAI positively influences student learning outcomes. These results align with earlier studies, such as [13], which found that CAI contributes to enhanced student performance by incorporating dynamic, interactive learning tools that make the educational experience more engaging. The engaging nature of CAI fosters an environment where students are more motivated to participate actively in the learning process, leading to improved comprehension and retention.

Additionally, research by [15] highlighted how CAI supports self-paced learning, allowing students to revisit content as needed, practice at their speed, and work through challenging material at a comfortable pace. This flexibility likely contributed to the superior performance of students in the CAI group, as it allowed them to better internalize the content according to their unique learning needs. Self-paced learning in CAI environments may be particularly beneficial for students in resource-limited settings, where they often lack access to individualized instruction and might benefit from additional time to master course material.

Consequently, the null hypothesis (H_{01}), which suggested that CAI would not significantly impact student learning outcomes, was disproven. The rejection of this hypothesis underscores CAI's potential as an effective educational tool, even in under-resourced areas such as Kano State. This finding supports the broader body of research indicating that CAI can elevate educational outcomes, making it a viable solution for enhancing learning in environments with limited instructional resources. The study's results suggest that implementing CAI could be a meaningful strategy for schools in similar settings aiming to improve academic performance, equipping students with a more accessible, individualized, and productive learning experience.

Hypothesis 2: Computer-aided instruction (CAI) is not an effective method for sustaining continuous learning during emergencies.

This study found that students exposed to Computer-Assisted Instruction (CAI) demonstrated notably higher levels of

engagement and satisfaction with their learning experience compared to those receiving conventional instruction methods. This outcome aligns closely with findings by other researchers, such as [15], who highlighted CAI's role in providing flexible and remote learning opportunities. These features are particularly beneficial during periods of educational disruption, where maintaining continuity becomes essential.

By offering adaptable instructional methods, CAI ensures students can continue learning regardless of location or situational challenges. This adaptability was especially significant during the COVID-19 pandemic when students worldwide faced restricted access to in-person classes and conventional educational resources. The present study's findings are consistent with Rosenberg's [15] research, which underscored CAI's flexibility during emergencies, stressing its capacity to support uninterrupted education through online or technology-enhanced platforms. The positive feedback from students engaged in CAI indicates that this approach not only facilitates content delivery but also sustains student motivation and participation under challenging circumstances.

Moreover, the outcomes confirm that CAI is not only an effective substitute for conventional learning but also a method that may surpass it in engaging students, offering them control over their learning pace, and making educational content more accessible. Given these results, the null hypothesis (H_{02}), which posited that CAI would not significantly impact student engagement and learning continuity, was rejected. This rejection substantiates CAI's effectiveness as a reliable instructional approach, particularly in times of crisis. These findings underline the potential of CAI to serve as a critical tool for educational institutions aiming to provide resilient learning solutions during unprecedented disruptions, ensuring students remain connected, motivated, and academically supported.

Hypothesis 3: Computer-aided instruction (CAI) cannot be effectively integrated into the regular curriculum of public universities in Kano State.

The findings further showed that students believed incorporating Computer-Assisted Instruction (CAI) into their regular curriculum could be feasible, with those in the CAI group demonstrating significantly better performance in practical assessments. This perspective supports previous research by [17], which emphasized the advantages of integrating CAI within a blended learning model that combines conventional face-to-face instruction with digital technology. Such a mixed approach maximizes the benefits of CAI, as it enables students to enjoy the structured guidance of in-person learning while also taking advantage of CAI's flexible, interactive, and individualized elements.

However, the study also identified potential barriers that could hinder the complete integration of CAI, especially in contexts like Kano State, where technological resources may be limited. For instance, factors such as restricted internet connectivity, insufficient access to digital devices, and inadequate technical support could challenge the effective implementation of CAI in local schools. Research by [1] similarly highlighted that these infrastructural limitations could affect the success of CAI, underscoring the need for targeted investments and policies to improve technology access in educational institutions.

Despite these possible challenges, the findings suggest that CAI could be successfully integrated into Kano State's educational framework with the necessary support and resources. This aligns with previous studies that explored the feasibility of CAI in educational contexts, particularly in regions where resource constraints may initially appear to be obstacles. The positive feedback from students indicates a readiness to embrace CAI, provided there is adequate infrastructure and institutional support. Consequently, the null hypothesis (H_{03}), which posited that CAI would not be feasible for inclusion in the regular curriculum, was rejected. This outcome reinforces the potential for CAI to enhance the educational experience when thoughtfully integrated, making it a promising tool for educational advancement in Kano State and similar environments.

6. Conclusion and Future Scope

The study's general findings support the beneficial effects of CAI on student learning, its capacity to maintain continuous instruction in times of emergency, and its viability for inclusion in regular curriculum. Constructivist learning theory [11] holds that knowledge is constructed by students through interactive, student-centered methods, and these results support this theory. This study fills the gaps in the literature by offering actual data that encourages educators and policymakers to consider CAI as a long-term educational approach to prepare for future disruptions.

Data Availability
Data supporting the findings of this study are available upon reasonable request. The dataset consisted of test scores collected from 360 respondents across two groups: the experimental group, which participated in computer-aided instruction, and the control group, which received conventional instruction. Data were gathered through structured questionnaires and included three distinct assessment scores for each respondent. Each participant's score was recorded in a comprehensive Excel spreadsheet, ensuring accurate documentation and facilitating subsequent statistical analysis. The reliability of the data was verified using Cronbach's alpha, which indicated good internal consistency among the scores. Interested researchers can request access to the dataset by contacting the corresponding authors.

Table:4 Reliability analysis Result for Experimental Group

Cronbach's Alpha	Number of Items
0.84	3

Source: Fieldwork

Table:5 Item-Total Statistics for Experimental Group

Item	Scale Mean if Item Deleted	Scale Variance if item deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Score 1	78.67	32.33	0.75	0.80
Score 2	79.00	30.67	0.73	0.79
Score 3	79.67	29.67	0.74	0.81

Source: Fieldwork

The Cronbach's Alpha coefficient of 0.84 for the experimental group signifies a high level of internal consistency, which is a strong indicator that the assessment instrument reliably measures the same underlying construct across items. In social sciences, a Cronbach's Alpha above 0.80 is considered excellent, demonstrating that the tool used to assess students in the experimental group consistently captures the intended aspects of learning performance associated with Computer-Assisted Instruction (CAI). This high-reliability score suggests that the responses from the students are systematic rather than random or erratic, providing confidence that the instrument effectively measures students' learning outcomes influenced by CAI.

Such a robust Cronbach's Alpha not only enhances the credibility of the findings but also assures that observed differences are more likely due to actual variations in students' learning experiences with CAI rather than inconsistencies in measurement. A reliability coefficient of this level affirms that the assessment items were well-constructed and relevant to capturing the core variables of student engagement, satisfaction, and learning outcomes. This is particularly valuable for research involving educational interventions, as it supports the instrument's ability to accurately reflect students' responses and experiences with CAI. Consequently, the findings drawn from this instrument are dependable, and the conclusions regarding the positive impact of CAI on student performance and engagement within the experimental group can be confidently supported.

Table:6 Reliability analysis Result for Experimental Group

Cronbach's Alpha	Number of Items
0.84	3

Source: Fieldwork

Table:7 Item-Total Statistics for Experimental Group

Item	Scale Mean if Item Deleted	Scale Variance if item deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Score 1	78.67	32.33	0.75	0.80
Score 2	79.00	30.67	0.73	0.79
Score 3	79.67	29.67	0.74	0.81

Source: Fieldwork

The Cronbach's Alpha coefficient of 0.75 for the control group indicates an acceptable level of reliability, suggesting that the assessment items used in this group were reasonably consistent in measuring the intended construct. In reliability terms, a Cronbach's Alpha of 0.70 to 0.79 generally falls within an acceptable range in social sciences research,

meaning that the instrument applied to the control group produces stable and relatively consistent scores. Although this reliability is adequate, it is somewhat lower than the reliability observed in the experimental group, where Cronbach's Alpha reached 0.84.

This slight difference suggests that, while the control group's assessment items reliably measured students' understanding, there may have been a bit more variability in their responses compared to the experimental group. Such variability could be due to the nature of conventional instruction, which may result in a broader range of engagement and understanding levels among students compared to the more structured and consistent approach of Computer-Assisted Instruction (CAI) used in the experimental group.

Nonetheless, the control group's reliability score still supports the validity of the findings, confirming that the instrument effectively captured the construct under investigation. Thus, the assessment of students in the control group can be considered credible, even though it demonstrates slightly less consistency than that of the experimental group, adding a valuable comparative aspect to the study's analysis.

Experimental Group: A Cronbach's alpha of 0.84 for the experimental group indicates excellent internal consistency, meaning that the items used to measure performance within this group were highly consistent in capturing the same underlying construct. This high-reliability score suggests that the assessment tool effectively measured the intended aspects of learning and engagement resulting from Computer-Assisted Instruction (CAI). With such strong internal consistency, it is evident that the responses of students in the experimental group were systematically aligned with their experiences and understanding, rather than showing random variations.

This level of reliability strengthens the confidence in the results, supporting the notion that CAI can contribute to a stable and dependable measurement of student performance. Such robust internal consistency implies that CAI has potential as a consistent instructional approach, enhancing not only student engagement but also the accuracy of assessments in evaluating learning outcomes effectively.

Control Group: A Cronbach's alpha of 0.75 for the control group indicates an acceptable level of reliability, showing that the assessment items were reasonably consistent in measuring performance. However, this reliability is somewhat lower than that observed in the experimental group, where Cronbach's alpha was 0.84. This difference suggests that conventional teaching methods may result in slightly more variability in students' responses, leading to less consistent performance measurements than those achieved through the Computer-Assisted Instruction (CAI) used with the experimental group.

The lower reliability in the control group implies that, while conventional instruction is effective to some extent, it may lack the structured, repeatable elements that CAI offers,

which can contribute to more stable and uniform outcomes. Consequently, this finding underscores CAI's potential advantage in providing a more reliable means of assessing student performance.

Implications: The observed difference in reliability between the experimental and control groups offers valuable insight for future research on the effectiveness of various instructional methods. With the experimental group, using Computer-Assisted Instruction (CAI), achieving higher internal consistency, this contrast suggests that CAI may provide a more stable framework for assessing student performance compared to conventional teaching methods. This difference could lead researchers to explore whether CAI's structured, interactive approach inherently fosters not only enhanced learning outcomes but also more consistent measurement of those outcomes.

Further studies could investigate how specific elements of CAI, such as its adaptability, interactive components, or pacing flexibility, contribute to this increased reliability. Additionally, examining these instructional methods across diverse educational settings and subjects could reveal whether CAI consistently supports reliable assessment, potentially guiding curriculum design and instructional practices in various educational contexts.

Conflict of Interest
All authors are required to disclose any real or potential conflicts of interest, including any financial, personal, or other relationships that may improperly affect or appear to affect their work. The authors affirm they have no conflicts of interest to declare.

Authors' Contributions
All authors contributed in various capacities. Specifically, the first author was responsible for drafting the initial manuscript. The second author played a vital role in developing the study's guidelines, securing ethical approval, recruiting patients, and conducting data analysis. Meanwhile, the third author carried out an extensive literature review and was instrumental in conceptualizing the study's framework. Each author's unique contribution helped shape the research, ensuring a comprehensive approach that strengthened the quality and rigor of the study from conception to execution.

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