Teachers' Instructional Design Skills, Students' Perception, and Mathematics Achievement

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Abstract

This study investigated teachers' instructional design skills, students' perceptions towards teachers' instructional design skills, and achievement in mathematics among senior secondary school 3 students in command secondary schools in Lagos State. The study employed a purposive sampling technique to select three districts and three local government areas that house Command secondary schools. A simple random sampling technique was used to select 10 Microsoft Certified Mathematics Educators and an intact class of 100 SS 3 students from each school. A total of 30 mathematics teachers and 300 students were sampled. The Teachers' Instructional Design Skills Observation Rating Scale (r = 0.79), the Students' Perception towards Teachers' Instructional Design Skills Questionnaire (r = 0.82), and the Mathematics Achievement Test (r = 0.78) were used for data collection. The data were analysed using multiple regression at the $p < 0.05$ significance level. The results revealed a positive association among teachers' instructional design skills, students' perceptions, and students' achievement in mathematics (R = 0.25). Also, 5.6% of the composite contribution of the variance was observed in student achievement in mathematics, which was statistically significant ($F_{(299)} = 9.94$). In addition, there is a relatively significant contribution of teachers' instructional design skills ($\beta = 0.23$; $t = 4.0$) and students' perceptions ($\beta = 0.12$; $t = 2.27$) to students' achievement in mathematics. It was concluded that Microsoft-certified training acquired by teachers enhances students' mathematics achievement. School authorities in Command secondary schools should periodically send teachers for training for innovative teaching strategies to aid students' assimilation and achievement.

Keywords: mathematics classroom observation, teacher instructional skills, achievement in mathematics, correlation of variables

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Introduction

Mathematics achievement among students is linked to a country's future economic strength and competitiveness. Global policymakers and educators share a desire to uncover factors that correlate with mathematical ability. Educational systems aim to educate students to apply mathematics in many circumstances, which is universally acknowledged (Alotaibi & Alyahya, 2019). Students' academic success is influenced by several factors, including instructional efficacy, curriculum content, environmental conditions, and available resources (Ahmad et al., 2017). Instructional design remains a crucial component of teaching and learning. The most successful teachers spend their time carefully planning and continually looking for ways to improve their lessons. Having the right environment to do this is crucial because often, the time needed to plan creative and effective lessons is not available, or there are insufficient resources. Instructional design skills are crucial for creating effective learning environments. Teachers who implement discourse-related practices, such as engaging students in verbal communication and encouraging the use of mathematical vocabulary, have a positive impact on students' mathematics achievement (Byiringiro, 2024). The methods employed by educators to teach mathematical concepts directly impact students' understanding of mathematical knowledge (Oladele et al., 2022).

Educational research has the power to single-handedly improve the teaching profession for current and future practitioners and, importantly, raise student achievement levels in mathematics. Instructional design is a method of devising instruction that is usually based on some teaching models (Bakhshi et al., 2017). Hiebert and Grouws (2007) stated that to improve mathematics teaching using instructional design, a teacher will need to employ the given model in a planned or systematic way that includes goal-specific strategies and techniques, with better implementation through various forms of delivery and revision, leading to higher student achievement. An increase in teacher skills can raise the standards of mathematics, especially in understanding, analysis, and knowledge. The subsequent impact on grades, perceptions, and attitudes could potentially increase the uptake of higher levels of mathematics and dispel the negative stereotype of the subject. The premise of this study is that enhancing mathematics instruction can positively influence student achievement and perception of the subject.

Available evidence at the local, state, and national levels in Nigeria shows that student achievement in mathematics needs to be improved. Teacher survey results showed that most of the instructional techniques employed by teachers were more teacher-centred than student-centred. The evaluation techniques implemented by the public examining authorities could be one possible explanation for the slightly above-average performance of students in mathematics in recent times (Oladele, 2021).

This survey research aims to investigate the prevalence and practices of instructional design skills among mathematics teachers, as well as their application to teaching and their influence on student learning in Command Secondary Schools in Lagos. The survey will further investigate the relationship between teachers' instructional design skills and student perception and achievement in mathematics. We will also take steps to promote instruction that is of higher quality and more closely connected to student achievement. This study will help fulfil the requirements of the military initiative to improve the educational system in command schools. According to Hirumi (2014) analysing the quality of teacher instructional design skills is a crucial component of instruction. It represents a sequence of strategic planning to enhance students' understanding in a systematic and organised way. Instructional

design is oriented towards the achievement of goals determined by the teacher, and it is instrumental in creating learning experiences that facilitate the understanding of students in the learning of a particular topic. The theory of instructional design guides a qualified teacher in implementing planned stages of learning to achieve the desired learning outcomes (Reiser & Dempsey, 2018). Student achievement in learning serves as a demonstration of the effectiveness of such an instructional design. Student achievement refers to the attainment of learning outcomes about the predetermined goal. Increased understanding of the transmitted information from a learning experience can influence high student achievement. Instructional design with high-quality skills will stimulate student thinking in understanding a topic, which is caused by the activities and learning experiences provided by the teacher. This is indicative of a student's reasoning; he will have success in understanding if he can match the reasoning to the level of understanding he wants to achieve. An increased understanding by a student of a topic is the start of an improvement in their perception of the topic. A teacher's instructional design has implications for understanding students because the learning experience can increase a student's understanding to achieve the expected learning outcomes.

Teachers have an essential influence on students's academic achievement. High-quality, knowledgeable skills and adaptability in teacher instructional practice are prerequisites for high educational achievement among students. Despite the remarkable growth and changes that have occurred in the field of education worldwide, it is a regrettable fact that the level of academic achievement among students is still far below expectations. This condition is also relevant to mathematics learning in Nigerian schools. This study highlights indicators of instructional design skills conceptualised in terms of collaboration, knowledge construction, innovation, and real-world problem solving, as well as the use of ICT for teaching and learning.

Collaboration simply means that it brings the students together in and outside the classroom to solve mathematical problems without barriers. That is when technology comes into the classroom with digital tools to enhance collaborative study. Collaboration refers to different students working as a team or in pairs or groups, not independently but as a group, to negotiate their ideas, share work fairly, and make substantive decisions about the work to complete a task (Glazer et al., 2005). To exchange ideas or resources, students can collaborate in person or via technology. Working in a group without technology is not applicable outside of the classroom. Hence, collaborative apprenticeship is designed to help teachers learn and implement new teaching skills and strategies through four development phases, beginning with the implementation of best practices.

The dimension of this instructional design skill called collaboration is "What does it mean to bring the students to work together in and outside the classroom to solve mathematical problems without barriers?" That is when technology comes in. Without technology, there is a barrier to learning because the only people who can come together are those close to each other or within a particular environment. Hence, with the means of technology, you can connect with people far and wide to collaborate to solve and share tasks. This is made possible using Microsoft Teams, Zoom, Google Meet, OneDrive, Padlet, Jamboard, Edmodo, etc. With these tools, students can work with other students outside their environment and learn simplified methods to solve mathematics. It is practical, engaging, interactive, and offers a feedback mechanism. Collaboration among teachers enables them to share best practices, resources, and instructional strategies related to mathematics instruction via Teams, Zoom, and Google Meet.

Knowledge construction happens when students do more than reproduce what they have learnt in mathematics into a new idea. The skills of knowledge construction are often considered "critical thinking." When students create new ideas based on what they have learnt in mathematics, they are engaging in knowledge creation. People frequently refer to knowledge construction abilities as "critical thinking." When students interpret, analyse, synthesise, or evaluate data or concepts, they gain knowledge. Knowledge construction simply means that after a course of study, did the student generate ideas that were new to them? What assessment activity did they spend the most time on? Did they demonstrate conceptual understanding? Is their work interdisciplinary? Can they apply it in a new situation to solve a problem that is new to them? When students do more than merely replicate what they have learnt in mathematics, knowledge creation takes place. The skills of knowledge construction are often considered "critical thinking." Students build knowledge when they interpret, analyse, synthesise, or evaluate information or ideas. The constructivist approach to learning emphasises that learners actively construct knowledge based on their prior experiences and mental structures (Dalgarno, 2001). In mathematics education, this means allowing students to build their understanding through hands-on activities, collaborative work, and meaningful problem-solving tasks. By constructing their knowledge, students develop a more robust and enduring understanding of mathematical concepts. Innovation and real-world issue-solving look at how well students solve problems and apply real-world information or scenarios to their work. In traditional education, students frequently generate work that has little to do with their experiences and observations in the real world. When students work to tackle a specific challenge, they exhibit problem-solving skills. Students who worked on problem-solving projects demonstrated their ability to solve new problems, finish tasks for which they had no instructions, or create intricate products that satisfied specifications.

The strongest student's work for this skill demonstrates that the student did not already know a response or solution to the task given but developed a successful solution to a real-world problem using his or her prior ideas, designs, or solutions. Innovation and real-world problem solving simply say what ways a learner can infer classroom analysis and results from the real world and what digital tool supports the study of mathematics that can enable us to apply it in the real world. We have digital software tools such as Geogebra, Microsoft Mathematics (Ogunleye, 2021), Maxima, Speomathematics, Axiom, Gretl, SasEuler, AI, YouTube, etc**.** Real-world problem-solving and innovation are skills used to incorporate digital tools into the teaching and learning of mathematics (Paige et al., 2016). Other digital tools relevant to mathematics are MatLab, Sage Math, SciLab, Photo Math, SpeQ Mathematics, SymPy, etc. It is students's confidence in their abilities to produce designed levels of performance that influence later events of their lives (Xu & Qi, 2019).

The use of ICT for teaching is a strategy that allows total lesson delivery using technological devices. An electronic interactive whiteboard, also known as an interactive smartboard, is one of the means of achieving interactive lesson delivery (Adeyemi & Olaleye, 2020). It is an advanced digital teaching tool that combines the function of a whiteboard surface with interactive capabilities and a built-in piece of software called "board." It allows educators to deliver dynamic and engaging lessons by integrating multimedia content, interactive software, and digital resources (Cheung & Slavin, 2013). It has a touch-sensitive surface, digital ink, and a writing stylus. The Smartboard comes with interactive software called Board embedded with graphs, geometric shapes, etc. Smartboards allow for seamless integration of multimedia elements, such as images, videos, audio files, and interactive simulations, into lesson delivery. Smartboards facilitate collaboration and group activities by

allowing multiple users to interact with the board simultaneously. They are flexible and can be customised to a lesson's content. Educators can easily switch between different media, rearrange elements on the board, and customise the display according to their teaching needs. The interactive nature of a smartboard enhances student engagement and participation in the lesson. Students can use the board to solve problems, manipulate shapes and objects, and actively contribute to the lesson, fostering a more interactive and student-centred learning environment. Smartboards often have internet connectivity, allowing educators to access a wealth of online resources directly from the board. It can browse websites, share lesson notes using OneDrive or Office 365, access educational databases, stream educational videos, expand the range of content available for instruction, and much more.

In a connected world with unprecedented access to a vast array of digital information and experiences, the use of technology continues to transform how we live and work. The ongoing adoption of new advances in ICT has become more essential to both lifelong learning and lifelong learning. In today's globalised, knowledge-based economies, individuals increasingly need skills not only to intelligently consume information and ideas but also to design and create new information and ideas using ICT. Despite the increasing prevalence of ICT in classrooms and learning environments, its primary function is to present or consume information, not to fundamentally transform learning experiences. This rubric examines how teachers use ICT devices in lesson delivery. Within the context of this rubric, "ICT" refers to the entire spectrum of digital tools that are currently available, encompassing both hardware (computers and related electronics devices, including tablets and notebooks, e-readers, smartphones, PDAs, camcorders, graphing calculators, and electronic whiteboards) and software (ranging from social media and engineering applications to Internet browsers, multimedia development tools, and Internet utilities). Technology can be used as a potent tool to support and encourage a variety of 21st-century skills.

Student perception is another variable in this study and could be referred to as the student's view about the effective usage of instructional design skills among Microsoft-certified educators. It encompasses the teacher's lesson planning, development, and implementation of effective teaching strategies to facilitate meaningful learning outcomes. The relationship between teacher-student interactions and mathematics achievement is mediated by students' perceptions and self-efficacy. While the direct impact of teacher-student relationships may be insignificant, fostering positive perceptions and self-efficacy can enhance achievement (Appiah et al., 2023; Hascher et al., 2024).

Although teachers bear the primary responsibility for instructional design, it is crucial to assess students' perspectives on the application of these skills in the classroom. This study explores the importance of students' perceptions of teachers' instructional design skill usage and its implications for the learning process. Students' positive perceptions could contribute to enhanced learning experiences, higher levels of engagement, and improved academic achievement. Conversely, negative perceptions may hinder learning, leading to decreased motivation and suboptimal performance. Students' perceptions of teachers' teaching skills contribute significantly to their learning outcomes, with a strong correlation observed between these perceptions and mathematics achievement (Hascher et al., 2024).

Several factors may influence students' perceptions of teachers' instructional design skill usage. These include the clarity of communication, relevance of content, alignment with students' learning needs, and incorporation of active learning strategies. Additionally, the use of technology, the classroom environment, and teacher-student interactions could play crucial

roles in shaping students' perceptions. Feedback mechanisms, such as assessments and evaluations, also impact how students perceive the effectiveness of instructional design. Creating engaging, relevant, and well-structured learning environments, teachers could foster positive perceptions among students, leading to improved academic performance. Continuously assessing and refining instructional design practices based on student feedback is essential for promoting effective teaching and learning in educational settings.

Students' academic achievement in mathematics generally has witnessed a persistent low performance in some core areas of mathematics topics such as construction, graphs, mensuration, circle geometry, trigonometry, bearing and distance, etc. over the years. Observations from the WAEC Chief Examiner's reports for various years reveal that poor performance in mathematics among senior secondary school students is evident, which could pose a great challenge to students' abilities to cope with real-world situations after secondary school education, especially in nations like Nigeria where science is very important to engender development in society.

Nonetheless, using a variety of teaching strategies, including discussion, inquiry, problem-based, teacher-centred, student-centred, and case methods, contributes to the low mathematical achievement of students (Karakaya & Priyo, 2021). However, such efforts yield minimal positive outcomes and inconsistent results, but none of these studies focus on the use of instructional design skills by Microsoft-certified educators (2022) to improve students' achievement in mathematics. Also, how students feel about their teacher using such a method while teaching and learning mathematics is paramount.

This study concentrates on instructional design as it represents a significant domain where enhancements in teaching and learning can occur. This study therefore investigated the extent to which teachers who are Microsoft Certified Educators (MCE) deployed instructional design skills (collaboration, knowledge construction, innovation, real-world problem solving, and use of ICTs) in teaching and students' perceptions towards teachers' use of instructional design skills in Command Secondary Schools in Lagos State, Nigeria. This study addressed and answered the following research questions:

1. What is the extent to which teachers' instructional design skills and students' perceptions towards teachers' use of instructional design skills jointly contribute to students' achievement in mathematics in Command Secondary Schools in Lagos State?
2. What are the relative contributions of teacher instructional design skills and students' perceptions of teachers' use of instructional design skills to students' achievement in mathematics in Command Secondary Schools in Lagos State?

Methodology

This study is a non-experimental, correlational research type. The study's population consisted of Microsoft Certified Educators (MCE) and SS 3 Mathematics students at Command Secondary Schools in Lagos State. The variables considered in this study include teachers' instructional design skills (collaboration, knowledge construction, innovation and real-world problem solving, use of information communication for teaching), student perceptions towards teachers' use of instructional design skills, and achievement in mathematics. The multi-stage sampling procedure was used, in which a purposive sampling technique was used to select three (3) districts (1, 5, and 6) and three (3) local government areas (LGA) where the command secondary schools are domiciled in Lagos State (each LGA

has one command secondary school). We used simple random sampling to select at least ten (10) Microsoft Certified Educators (MCE) in each school. Additionally, we selected an intact class of SS 3 students. From each school, 100 students in SS 3 Mathematics were selected. In all, a total of 30 mathematics teachers (MCE), 10 teachers from each school, and 300 SS 3 mathematics students were sampled. Three instruments were used for data collection: the Teachers' Instructional Design Skills Observation Rating Scale (TIDSORS), the Students' Perceptions towards Teachers Instructional Design Skills Questionnaire (SPTIDSQ), and the Mathematics Achievement Test (MAT). The reliability of the instrument (TIDSORS) was established using Ordinal Alpha, which yielded 0.79. The reliability of the instrument (SPTIDSQ) was established using Ordinal Alpha, which yielded 0.82. The reliability of the instrument's internal consistency (MAT) was estimated using Kuder Richardson (KR20), which yielded 0.78. We sought and obtained approval from the Command Secondary Schools authority in Lagos State to conduct the research. The consent of the participants was ensured by informing them about the purpose of the study before the administration of the instruments, and after the administration, the instruments were collected from the respondents for analysis. We collected data from both teachers and students. The data collected for this study was analysed using multiple regression at a 0.05 level of significance.

Results and Presentation of Findings

Research Question 1: To what extent would teacher instructional design skills and students' perceptions towards teachers' use of instructional design skills jointly predict students' achievement in mathematics in Command Secondary Schools in Lagos State?

Table 1

Regression Summary and Anova of Teacher Instructional Design Skill and Students' Perception Towards Teachers' Use of Instructional Design Skills on Achievement in Mathematics

Multiple R	= 0.25
R Square	= 0.06
Adjusted R Square	= 0.06
Standard Error	= 1.22

Analysis of Variance

Source of Variance	Sum of Square	df	Mean Square	F	p-value
Regression	29.79	2	14.90		
Residual	444.88	279	1.498	9.94	0.00
Total	***474.67***	***299***			

Significant at $p < .05$

Table 1 presents the regression and ANOVA results of teachers' instructional design skills and students' perceptions towards teachers' use of instructional design skills on students' achievement in mathematics in Command Secondary Schools in Lagos State. The result in the table shows that the multiple correlation coefficients (R) of the combined independent variables with students' achievement in mathematics are 0.25. This implies that there is a positive and moderate association between teacher instructional design skills, students' perceptions of teachers' use of instructional design skills, and students' achievement in mathematics. The adjusted R2 indicates that the combination of independent variables accounts for a variability of 0.056 in the dependent variable. This implies that the independent variables contributed 5.6% to the variance observed in students' achievement in mathematics. Furthermore, the regression of ANOVA was statistically significant ($F_{(299)} =$

9.944, p = 0.00). This implies that the joint contribution of the independent variables considered in this study positively influenced the students' achievement in mathematics.

Research Question 2: What are the relative contributions of teacher instructional design skills and students' perceptions towards teachers' use of instructional design skills to students' achievement in mathematics in Command Secondary Schools in Lagos State?

Table 2
Relative Contributions of Teacher Instructional Design Skill and Student's Perception towards Teachers' Use of Instructional Design Skills in the Prediction of Students' Achievement in Mathematics

Variables	Unstandardized Coefficients		Standardized Coefficients	t	p-value
	B	Std. Error	Beta		
(Constant)	42.968	3.220		13.344	0.000
Tea. Instru. Design Skill	0.075	0.019	0.226	4.008	0.000
Students Perception	0.013	0.006	0.128	2.274	0.024

Significant at p < .05

Table 2 presents the relative contributions of the independent variables to the criterion variable (students' achievement in mathematics). The independent variables contributed significantly to students' achievement in mathematics. That is, teacher instructional design skill (β = 0.226, t = 4.008, p = 0.000) and students' perception (β = 0.128, t = 2.274, p = 0.024). The value of the standardised regression weight associated with the two variables shows that teacher instructional design skills are potent predictors of students' achievement in mathematics. This implies that teachers' use of instructional design skills positively influenced students' achievement in mathematics.

Discussion of Findings

The findings of this study on the joint contribution of teachers' instructional design skills and students' perceptions towards teachers' use of instructional design skills on students' achievement in mathematics in Command Secondary Schools in Lagos State reveal a positive and significant relationship between the predictor variables and criterion variables. It was also found that the predictor variables contributed 5.6% of the total variance observed in the criterion variable, while the remaining 94.4% could be due to other variables not considered or controlled for in this study. The findings of this study are in line with those of Cheung and Slavin (2013), who found that the use of educational technology applications had a significant positive effect on student achievement in mathematics, with an overall effect size of 0.16. This finding was found to align with that of Hattie (2009), who found the relationship between teachers and students plays a significant role in shaping student perception. In other words, one could say that positive teacher-student relationships, characterised by mutual respect, trust, and open communication, foster a positive perception of learning experiences. The finding from this study also aligns with that of Trigwell et al. (1999) who assert that by understanding student perceptions, instructional designers can tailor their instructional strategies to better align with student needs, preferences, and learning styles. By this, one could say that the Command secondary school students had a better understanding and were aligned with the instructional design skills being used by the Microsoft Certified Educators. This could potentially explain why most of them demonstrated improved performance.

The findings of this study on the relative contributions of teachers' instructional design skills and students' perceptions towards teachers' use of instructional design skills to students' achievement in mathematics in Command Secondary Schools in Lagos State reveal that both predictor variables relatively and significantly influenced students' achievement in mathematics. However, teachers' use of instructional design skills was found to be a potent predictor. This study agrees with that of Freeman et al. (2014) and Mergendoller et al. (2006), whose studies consistently demonstrated that active learning strategies, such as collaborative learning and problem-based learning, enhanced student achievement in mathematics. Similarly, the findings of this study are consistent with those of Cheung and Slavin (2013), whose study found positive effects of technology-enhanced instruction on student achievement in mathematics when implemented with sound instructional design principles. Computational thinking skills, including problem-solving and critical thinking, are essential components of instructional design that can improve students' performance in mathematics assessments like TIMSS (Shone et al., 2023). Also, the findings of this study corroborate those of Li and Ma (2010), who found that the use of computer technology had a significant positive effect on student achievement in mathematics, with an overall effect size of 0.28. This study supports that of Selden and Selden (2005), who found that the use of real-world problem-solving tasks had a significant positive effect on student achievement in mathematics, with an overall effect size of 0.41.

Real-world problem-solving tasks are also one of the indicators of teachers' instructional design skills in this study. One can say that, comparing the variance observed in this study with the effect size of previous studies reported, the instructional design skills in this study had a greater contribution to students' achievement in mathematics. Furthermore, Students' perceptions of mathematics and their self-efficacy are strong predictors of their mathematics achievement. A study found that these factors accounted for 75.4% of the variance in students' mathematics achievement, highlighting their significant impact (Appiah et al., 2022). Positive perceptions of instructional quality, such as cognitive activation and effective classroom management, are associated with better mathematics achievement. However, negative emotions like boredom can also influence outcomes (Alotaibi & Alyahya, 2019).

Conclusion

This study investigated teachers' instructional design skills, students' perceptions towards teachers' use of instructional design skills and students' achievement in mathematics in Command Senior Secondary Schools in Lagos State. In this study, it was found that teachers' use of instructional design skills in teaching and learning mathematics is a potent predictor of students' achievement in mathematics. This was also affirmed by the significant influence of students' perceptions on teachers' use of instructional design skills. The underlying assumption here is that Microsoft-certified training acquired by teachers at Command Senior Secondary Schools in Lagos State contributes to the improvement of students' mathematics achievement.

Recommendations

The study's conclusions and findings led to the following recommendations:

1. Teachers in Command Senior secondary schools should adopt collaborative knowledge construction, innovation, real-world problem-solving, and the use of ICTs during the teaching and learning of mathematics and other subjects to stimulate learning.

2. Other teachers, especially those in the core sciences, should enroll in Microsoft training to enhance their lesson delivery with modern skills and technologies.
3. The school authorities should periodically send teachers for training that would equip them with innovative teaching strategies to aid students' assimilation.
4. The school management should embed activities that involve collaboration, knowledge construction, innovation, real-world problem-solving, and the use of ICTs in the school curriculum.

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