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STUDENTS' ATTITUDES TOWARDS PLICKERS IN UNDERGRADUATE CALCULUS COURSE

Adeneye O. A. AWOFALA, Modiu K. OLAGURO, Samuel A. OLAOLUWA

Abstract: In university education, lecturers often adopt didactic lectures in undergraduate calculus classes. This method has been judged for making students passive recipients of calculus knowledge who cannot construct their own knowledge of the discipline. One way to make didactic lecture more interactive and engaging in calculus class is to encourage lecturers to integrate elements such as visual aids, real-life examples, stories or anecdotes, questions and discussion, and interactive technologies like polls or quizzes into calculus teaching. One interactive technology currently gaining ground in higher education is Plickers. Plickers is a relatively new audience response system (ARS) tool that allows a lecturer to collect real-time feedback from students using a mobile app and paper-based cards to inform instruction. This study investigated students' attitudes towards Plickers as a low-cost pedagogical tool to foster active learning in an undergraduate calculus course. A quantitative approach within the scheme of a cross-sectional survey design was adopted and primary data relating to attitudes towards Plickers were collected with a valid and reliable instrument tagged Attitudes towards Plickers in Calculus Scale (ATPCS, Cronbach's alpha Coefficient =0.96) from 336 undergraduate calculus students. Data was analyzed using descriptive statistics of mean, standard deviation, percentage, and frequency and inferential statistics of an independent samples t-test. Results revealed that all the students had positive attitudes towards Plickers in calculus instruction. Additionally, there was a significant influence of gender on calculus students' attitudes towards Plickers in favour of the females ($t_{(2,\ 334)} = -2.89$, p=0.004). The findings showed that when implemented effectively, Plickers helped to sustain and improve students' attitudes in calculus instruction. This study recommended the adoption of Plickers as a low-cost alternative to the deficiencies inherent in didactic lecture.

Key words: Attitudes, undergraduate, students, plickers, calculus

1. Introduction

The word calculus evokes anxiety among undergraduate students in science, technology, engineering, and mathematics (STEM). In Ugandan universities, calculus is a compulsory course for all undergraduate students in STEM fields. It is an advanced course in which undergraduate students often perform poorly (Awofala & Odogwu, 2017). Calculus is a prerequisite for taking more advanced courses such as mathematical methods and differential equations in Ugandan universities. Thus, calculus could be regarded as a gate-keeping course (Wilkins, Bowen, & Mullins, 2021). In most universities in Uganda, calculus is taught through didactic lectures. In didactic lectures, the lecturer is a sage on the stage, who dishes out knowledge to passive students. With didactic lecture, the lecturer follows a one-way communication in which structured calculus contents are delivered by the authority figure whose sole aim is to transmit calculus knowledge with limited student interaction. The advantages of didactic lectures in a traditional calculus class are principally a clear organization and structure, efficiency in presenting complex calculus information, and efficient ways to cover large amounts of calculus contents (Arigbabu & Awofala, 2023). Disadvantages of didactic lectures include limited opportunities for student interaction and engagement, the inability to adapt to the needs of students with different learning styles, and the fact that they are passive and boring for most students. (Arigbabu et al., 2023).

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However, calculus students need competencies in communication skills, self-directed learning, problem-solving, teamwork, and critical thinking (Awofala, & Lawal, 2022; Awofala, Ojo, Okunuga, Babajide, Olabiyi, & Adenle, 2019; Okunuga, Awofala, & Osarenren, 2020), all of which are scarcely available during didactic lectures. One way to make didactic lectures more interactive and engaging is to encourage lecturers to integrate elements such as visual aids, real-life examples, stories or anecdotes, questions and discussion, and interactive technologies like polls or quizzes. It is hoped that by integrating engaging and interactive elements into didactic lectures, lecturers can help design and create a more enjoyable and effective learning experience for the undergraduate students. The more effective the interaction between the lecturer and the students, the more effective the students' learning experience. It is important that students engage in the business of creating their calculus experience through active learning and by becoming more involved with the real-life situations. Therefore, fostering a supportive learning environment that actively engages students can reduce their anxiety about calculus and enhance their understanding of the course.

Today, there is a paradigm shift from the conventional method of raising hand in the classroom to answer questions from the lecturer to a more technology-oriented audience response system (ARS). An ARS is a technology tool that allows students to partake in a meeting, lecture, and presentation by responding to prompts or questions in real-time. ARS is also called interactive polling or clicker system. Examples of ARS include: PollEverywhere, Mastery Connect, Kahoot, TurningPoint, Socrative, Mentimeter, Clickers, Slido, Quizlet, and Plickers. It is evident that the integration of ARS into teaching helps to enhance students' learning performance (Elmahdi, Abdulghani, & Fawzi, 2018), improve class attendance, increase students' attention and participation (Aricò & Lancaster, 2018; Kay & LeSage, 2009; Ma, Steger, Doolittle, & Stewart, 2018), enhance ability to track and analyse students' responses (Masita & Fitri, 2020; Mshayisa, 2020) and provide real-time feedback and assessment (Chng & Gurvitch, 2018; McCargo, 2017). In this study, attitudes towards Plickers would be studied in undergraduate calculus course. Attitude towards Plickers in this study is defined as an emotional response to Plickers in conjunction with beliefs about Plickers, and behaviour related to Plickers. Plickers is a relatively new ARS tool that allows a lecturer to collect real-time feedback from students using a mobile app and paper-based cards to inform instruction. Plickers tool is usually adopted in educational contexts for data collection and analysis, students' participation and engagement, class debates and discussion, polls and quizzes, and formative assessments (Masita & Fitri, 2020). In spite of the potential benefits of Plickers in classrooms all over the world, few studies have reported the adoption of this instructional tool in undergraduate classes (Mshayisa, 2020). More so, there is a scarce literature on students' attitudes towards Plickers in undergraduate calculus course. Although, the benefit of Plickers is widespread, little is known regarding students' attitudes towards Plickers in undergraduate calculus course in Uganda. Therefore, the present study investigated students' attitudes towards Plickers in undergraduate calculus course in Uganda.

1.1 Research Questions

The following research questions would be answered in this study.

RQ1. What is the level of attitudes towards Plickers in undergraduate calculus course?

RQ2. What is the influence of gender on attitudes towards Plickers in undergraduate calculus course?

2. Literature Review

Plickers is one of the web 2.0 technology assessment tools that is currently gaining ground globally. Web 2.0 technology is defined as the second generation of the World Wide Web (WWW), characterized by dynamic content, interactive features and enhanced students' experience. Plickers enables a swift response for formative assessment, remedial, and reflective teaching (Masita & Fitri, 2020). It is a simple technology that does not require the utilization of any gadgets by students. Plickers tool adopts QR (Quick Response) code cards to harness answers from the students without requiring connectivity to the internet or electronic device. Only the lecturer needs a smartphone with Plickers mobile application to scan the QR codes displayed by the students. The lecturer needs internet connectivity to be able to project the questions along with the correct options and graphics. The lecturer also needs a projector integrated with a laptop or computer for the display of correct options to

the questions put across to the students. Plickers cards are free for download from the Plickers' website and up to 63 QR code Plickers cards can be downloaded and printed for instructional purpose in the calculus classroom.

Before administering Plickers cards to students, the lecturer must complete a simple spreadsheet that associates each student with a Plickers card. The lecturer, through online instructions, can also add students' lists and class sections to the Plickers' website. After the lecturer asks a question, students respond by raising the Plickers card face up, with one of the four options they consider correct, and answering the question. With all the Plickers cards raised face up, the lecturer scans each student card with Plickers app camera feature on the mobile phone. Consequently, a visual bar chat that displays the responses of the students in terms of those that pick A, B, C, and D is shown on the laptop for everyone to see. With this, the lecturer can determine the level of understanding of the students in the concept being taught (Howell, Tseng & Colorado-Resa, 2017).

A lot of studies have been conducted on the use of Plickers. Pebriantik and Siswantara (2023) investigated the perceptions of Indonesian university students on the use of Plickers as a formative assessment tool within the blueprint of a qualitative paradigm. Findings revealed that the eleven pharmacy students that made the sample of the study had a positive perception towards Plickers. They considered Plickers to be more efficient, effective, fun and modern when compared with the traditional assessment format. The study highlighted the weaknesses and strengths of the Plickers as an assessment tool. Masita and Fitri (2020) through a mixed methods approach of an exploratory sequential design investigated the use of Plickers for formative assessment of vocabulary mastery among 29 Indonesian English language students. The results revealed that the adoption of Plickers aided the teacher in examining, executing, and preparing formative assessments for the students. Also, the study showed that the use of Plickers improved students' participation and motivation in learning English language. Hassan and Hashim (2021) investigated the influence of Plickers on Malay primary pupils' perceptions and motivation to learn vocabulary in English as a Second Language (ESL) through a mixed-methods research design. The sample consisted of 50 primary pupils and the results of the study revealed that Plickers made positive contributions to pupils' perceptions and that they were intrinsically motivated to use Plickers in learning English vocabulary.

Nunes, Catarino, Martins and Nascimento (2023) investigated the effect of Plickers usage to support similarities learning on 7th grade students of Portuguese basic education through a quasi-experimental study. The results showed that the Plickers group recorded adequacy in carrying out tasks, positive increase in motivation, fewer dropouts in accomplishment, less demotivation, more involved participation in tasks, higher persistence, more active learning, lower anxiety, spent less time on tasks, and had a higher involvement level in learning than the control group. In addition, the results showed that the Plickers group recorded a greater learning gain than the control group, in the sense that completing similar content creation tasks through Plickers demonstrated greater effectiveness and promoted greater student learning progression, compared to the control group treated with the paper format. Chou (2022) examined the effects of Plickers on rural students' learning outcomes via two case scenes. In the first case of pre-experimental study involving 24 students, the results showed that students' overall attitudes toward Plickers in English class remained positive. In the second case of quasi-experimental pretest and posttest research design involving 60 students, the results revealed that Plickers enabled students to achieve greater learning performance and improvement during mathematics instruction than the non-Plickers students. The study concluded that students' perceptions of Plickers were similar in both cases, in terms of active engagement and joyful learning when Plickers was used as a learning assessment tool.

Babacan and Güler (2022) investigated the effects of Plickers on English vocabulary achievement, motivation and anxiety among 61 ninth grade Turkish students. Results showed that the use of Plickers significantly increased the motivation and academic achievement of the experimental group than the control group without Plickers. More so, the adoption of Plickers led to a decrease in anxiety level of the students compared to the control group that recorded elevated anxiety level. Mshayisa (2020) investigated perceptions of Plickers and crossword puzzles in undergraduate course of food science and technology within the scheme of mixed-method survey consisting of 121 South African students. Results showed that crossword puzzles and Plickers enhanced students' engagement greatly and that

they should be considered as low-cost alternatives to the disadvantages inherent in the didactic pedagogy.

It is clear that most of the reviewed studies shed more light on Plickers as a formative assessment tool that can help to enhance students' quality of learning in anxiety, excitement, academic engagement, motivation, participation, interest, achievement, and performance. All these studies saw Plickers as an instrument to promote and transform assessment positively in the classroom. Formative assessment is defined as the process of gauging student learning and understanding during the instructional process, rather than at the end of a unit or lesson. Worldwide, formative assessment is the assessment for learning usually used to inform instruction, improve students' learning outcomes, and adjust teaching strategies (Masita & Fitri, 2020; Mshayisa, 2020). Although Plickers is regarded as a popular web-based formative assessment tool used by researchers and teachers (Wood, Brown, & Grayson, 2017), its popularity in the Ugandan education system is low. The dearth of studies on Plickers in Uganda shows that the use of Plickers is not widespread in Uganda. A look at the recent studies reviewed above shows that no study was carried out in Uganda. The study by Agbatogun (2014) in Nigeria revealed the impact of clickers on communicative skill of ESL learners with clickers group showing better performance in communicative skills development than the non-clickers group. This study shows the need to integrate Plickers into teaching and learning to promote effectiveness on the part of both the teachers and the students. However, few studies have targeted higher education students (Mshayisa, 2020; Pebriantik & Siswantara, 2023) and students' attitudes towards Plickers in calculus course is yet to be determined in Uganda. Only one study investigated students' attitude towards Plickers in English language (Chou, 2022) and not on tertiary students. The present study is being conducted to close the gap in literature on attitudes towards Plickers among university students. Worldwide calculus has become an intriguing course that students often record low performance in it, and the study about the university students' attitudes towards Plickers in calculus in Uganda is still rare. The study could help to garner data on the attitude of university students towards the use of Plickers in calculus class in Uganda.

3. Research Methods

3.1. Research Design

In this study, a non-experimental quantitative research within the blueprint of a cross-sectional survey design was implemented. This design was partly adopted because it enabled the researchers to collect data at a single point in time from the sample of participants (Awofala, Olaguro, Fatade, & Arigbabu, 2024). Also, the cross-sectional design not only allowed for the inclusion of large samples, but also allowed for the description of the behaviors, attitudes, and characteristics of the population studied (Awofala et al., 2024).

3.2. Participants

The population of the study consisted of all freshmen second semester students (N=420) in a popular private university in Kampala, Uganda. Freshmen in their second semester offering Calculus (HEC 1220) were taught through the blended learning approach in which Plickers technology was used in conjunction with face-to-face instruction. The three hours per week course consists of only the theory component. A representative sample of the population amounting to 336 (80% of 420) formed the sample of the study. This sample was selected through a simple random sampling technique where every participant in the population has every chance of being selected. The age of the participants oscillated from 16 to 35 years ($Mean_{age}$= 20.4 years; SD= 3.1 years). 136 participants were Moslems while 200 were Christians. 137 (40.8%) were females while 199 (59.2%) were males.

3.3. Instrument

One research instrument was used to collect primary data in this study. The instrument called the Attitudes Towards Plickers in Computing Scale (ATPCS), which contains two sections, was developed for the purpose of this study. The first section contained the biodata of the participants which included gender, age, and religion. The second section contained 30 items (15 negative and 15 positive messages) constructed by the researchers through searching of literature on the use of Plickers. The items were hinged on a five-point Likert scale of Strongly Agree-5, Agree-4, Undecided-

3, Disagree-2, and Strongly Disagree-1 for positive messages while the reverse was the case for all negative messages. Initially, 50 items on ATPCS were crafted and given to three experts on Affect for a review. The review led to the reconstruction of some item messages while some items were removed for non-clarity to the target audience. This led to the pruning down of the items on the ATPCS to 30. After the face and content validity of the items, the researchers pilot-tested the ATPCS on a sample of calculus students who were not part of the study, to highlight the internal consistency of the instrument. Cronbach's alpha coefficient was used to determine this and a reliability coefficient of 0.96 was computed. This value was considered high and so the ATPCS could be used for further investigation. A soft copy of the ATPCS was created using the Google forms and this was shared via WhatsApp social media platform to the sample of the study.

3.4. Method of Data Collection

A WhatsApp platform was created for the sample selected for the study. All the participants had previously indicated their willingness and readiness to take part in the study through the informed consent shared with them. The Google forms was sent to the sample group WhatsApp platform and each participant was expected to fill out and submit their responses.

3.5. Method of Data Analysis

The classical psychometric property of the ATPCS through the Cronbach's alpha was determined. The primary data collected through Google forms were transported into SPSS version 25 for data analysis. Research question one, which targeted the level of attitudes toward Plickers in the undergraduate university calculus course, was answered using the descriptive statistics of frequency, percentage, mean, and standard deviation. Research question two on the influence of gender on attitudes towards Plickers in undergraduate calculus course was answered using an independent samples t-test. All statistical tests were carried out at 5% level of significance.

4. Results

4.1. Research Question One: What is the level of attitudes towards Plickers in undergraduate calculus course?

In the ATPCS, the score ranged from 30 to 150. A score of 90 is the middle point so higher scores indicate high attitudes towards Plickers. Of the 336 students in calculus, no student had scores lower than 90, no student had scores equal to 90, while 336 (6.14%) had scores higher than 90 (M = 141.69, SD = 9.67, score range: 120-150, 95%CI = 140.65–142.72). Thus, all the calculus students had high attitudes towards Plickers. Table 1 shows the general pattern of calculus students' attitudes towards Plickers. According to table 1, 100% of the calculus students agreed/strongly agreed to the message 'Plickers makes calculus more accessible and enjoyable' (Item 1). 100% of the calculus students agreed/strongly agreed to the message 'I enjoy using Plickers to collaborate with peers in calculus' (Item 2). 100% of the calculus students agreed/strongly agreed to the message 'Plickers provides accurate feedback on my calculus understanding' (Item 3). 100% of the calculus students agreed/strongly agreed to the message 'I appreciate the ease of use of Plickers in calculus' (Item 4). 100% of the calculus students agreed/strongly agreed to the message 'Plickers helps me stay motivated in calculus class' (Item 5).

Table 1. General Pattern of Calculus students' Attitudes towards Plickers

No	Item message	Frequency (%)						
		SA	A	U	D	SA	Mean	Std. Dev.
1	The Plickers tool makes calculus more accessible and enjoyable.	292 (86.9)	44 (13.1)	-	-	-	4.87	0.34
2	I enjoy using Plickers to collaborate with peers in calculus.	260 (77.4)	76 (22.6)	-	-	-	4.77	0.42
3	The Plickers tool provides accurate feedback on my calculus understanding	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45

4	I appreciate the ease of use of Plickers in calculus.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
5	The Plickers tool helps me stay motivated in calculus class.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
6	I believe Plickers tool improves my understanding of calculus concepts.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
7	The Plickers tool provides a fun and interactive way to learn calculus.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
8	I like how Plickers tool allows me to anonymously ask calculus questions.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
9	The Plickers tool enhances my engagement with calculus homework.	237 (70.5)	98 (29.2)	1 (0.3)	-	-	4.70	0.46
10	I find Plickers to be an effective tool for calculus assessments.	234 (69.6)	100 (29.8)	1 (0.3)	1 (0.3)		4.69	0.49
11	The Plickers tool helps me identify areas where I need extra help in calculus.	225 (67.0)	110 (32.7)	-	1 (0.3)	-	4.66	0.49
12	I appreciate the instant feedback from Plickers in calculus.	292 (86.9)	44 (13.1)	-	-	-	4.87	0.34
13	The Plickers tool makes calculus more interactive and fun.	260 (77.4)	76 (22.6)	-	-	-	4.77	0.42
14	I enjoy using Plickers to engage with calculus material.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
15	The Plickers tool helps me understand calculus concepts better.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
16	I do not think Plickers is effective for calculus	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
17	The Plickers tool requires too much training or support for calculus.	292 (86.9)	44 (13.1)	-	-	-	4.87	0.34
18	I have experienced technical issues with Plickers in calculus.	260 (77.4)	76 (22.6)	-	-	-	4.77	0.42
19	The Plickers tool is not user-friendly for calculus students.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
20	I find Plickers to be confusing to use in calculus.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
21	I prefer traditional teaching methods over using Plickers in calculus.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45
22	The Plickers tool is too technical for my comfort level in calculus.	245 (72.9)	91 (27.1)	-	-	-	4.73	0.45
23	I don't see the value in using Plickers for calculus assessments.	242 (72.0)	94 (28.0)	-	-	-	4.72	0.45

24	The Plickers tool takes too much time away from regular calculus instruction.	211 (62.8)	125 (37.2)	-	-	-	4.63	0.48
25	I find Plickers to be a distraction in calculus class.	222 (66.1)	114 (33.9)	-	-	-	4.66	0.47
26	I feel like the Plickers tool is spying on me in calculus class.	232 (69.0)	104 (31.0)	-	-	-	4.69	0.46
27	The Plickers tool makes me feel less confident in my calculus abilities.	221 (65.8)	115 (34.2)	-	-	-	4.66	0.48
28	The Plickers tool is too complicated for calculus.	231 (68.8)	105 (31.3)	-	-	-	4.69	0.46
29	I think the Plickers tool is unnecessary in calculus.	218 (64.9)	118 (35.1)	-	-	-	4.65	0.48
30	The Plickers tool is not user-friendly in calculus class	215 (64.0)	121 (36.0)	-	-	-	4.64	0.48

Note: U=undecided, SD=strongly disagree, D=disagree, A=agree, SA=strongly agree

All calculus students (100%) agreed or strongly agreed with the following statements: Plickers improves their understanding of calculus concepts (Item 6); It offers a fun and interactive way to learn calculus (Item 7); They appreciate the anonymity Plickers provides when asking questions (Item 8); They value the instant feedback received through Plickers (Item 12); Plickers makes calculus more engaging and enjoyable (Item 13); They enjoy using Plickers to interact with calculus material (Item 14); and Plickers enhances their comprehension of calculus concepts (Item 15). A large majority also expressed high agreement: 99.7% agreed that Plickers boosts their engagement with homework (Item 9). 99.4% agreed that it is an effective assessment tool (Item 10). 99.7% agreed that it helps identify areas where they need extra support (Item 11).

Conversely, all students (100%) disagreed or strongly disagreed with negative perceptions of Plickers in calculus, including the statements: "Plickers is not effective for learning" (Item 16); "It requires too much training or support" (Item 17); "I have experienced technical issues using it" (Item 18); "It is not user-friendly" (Item 19); "It is confusing to use" (Item 20); and "I prefer traditional teaching methods over Plickers" (Item 21). Additionally, all students (100%) disagreed or strongly disagreed with negative perceptions of Plickers in calculus, including the statements: "It is too technical for my comfort" (Item 22); "It has no value for assessments" (Item 23); "It takes too much time away from instruction" (Item 24); "It is a distraction in class" (Item 25); "It feels like surveillance" (Item 26); "It lowers my confidence in calculus" (Item 27); "It is too complicated" (Item 28); "It is unnecessary in calculus" (Item 29); and "It is not user-friendly in class" (Item 30).

4.2. Research Question Two: What is the influence of gender on attitudes towards Plickers in undergraduate calculus course?

Table 2. Independent Samples t-test analysis of calculus students' attitudes towards Plickers based on gender

Construct	Gender	N	Mean	SD	Std. Error Mean	Df	t	p
Attitudes towards Plickers in Calculus	Male	199	140.44	10.26	0.73	334	-2.89	0.004
	Female	137	143.50	8.44	0.72			

Table 2 showed the independent samples t-test analysis of calculus students' attitudes towards Plickers based on gender. As contained in the table, male students recorded a low mean score (M=140.44, SD=10.26) compared with their female counterparts whose mean score was higher (M=143.50, SD=8.44) regarding attitudes towards Plickers. This difference in mean score was statistically significant ($t_{(2,\ 334)} = -2.89$, p=0.004) when an independent samples t-test was computed. This result showed that there was a statistically significant influence of gender on calculus students' attitudes towards Plickers technology in the present study.

5. Discussion

All the calculus students in the present study exhibited a very high attitude toward Plickers. This finding is explainable. Plickers makes learning calculus more enjoyable and even fun (Babacan & Güler 2022; Mshayisa, 2020; Nunes et al., 2023; Pebriantik & Siswantara, 2023). The Plickers tool increases motivation, as students see their progress and understanding improve over time (Elmahdi, Abdulghani, & Fawzi, 2018; Nunes et al., 2023). Plickers help lecturers tailor their teaching to meet individual students' needs, promoting a more personalized learning experience (Mshayisa, 2020; Nunes et al., 2023). Plickers facilitate group work and discussions, promoting collaborative learning and problem-solving (Mshayisa, 2020; Nunes et al., 2023). When Plickers is used for frequent, low-stakes assessments, it can help students identify areas where they need extra support (Mshayisa, 2020). The Plickers tool helps visualize complex calculus concepts, making them more accessible and easier to understand (Nunes et al., 2023; Ruisoto & Juanes, 2019). Plickers can be used anonymously, reducing student anxiety and encouraging honest responses (Babacan & Güler 2022; Nunes et al., 2023). This tool provides instant feedback, allowing students to track their understanding and progress in real-time (Chng & Gurvitch, 2018; McCargo, 2017) and increases student engagement and participation in class, making learning enjoyable and interactive (Ma, Steger, Doolittle, & Stewart, 2018; Kay & LeSage, 2009; Aricò & Lancaster, 2018).

In the present study, gender had a statistically significant influence on calculus students' attitudes towards Plickers. This result implied that both male and female calculus students had differential attitudes towards Plickers. Female students had higher attitudes towards Plickers than the male students. Generally, some investigations had found a statistically significant effect of gender on students' learning outcomes in mathematics (Anokye-Poku & Ampadu, 2020; Awofala, Arigbabu, & Awofala, 2013; Efa & Frimpong, 2023) while others had corroborated no significant gender influence on attitudes toward mathematics (Awofala, 2017, 2016). In most African countries, including Uganda, mathematics is considered a masculine domain (Anokye-Poku & Ampadu, 2020; Awofala, 2016; Awofala & Anyikwa, 2014; Efa & Frimpong, 2023; Ogunleye, Awofala & Adekoya, 2014). But the result of this study had shown otherwise. Female students seemed to have benefited more from Plickers instruction in the calculus classroom than their male counterparts. The findings of this study suggest that the traditionally masculine perception of mathematics or calculus appears to be diminishing in the context of Plickers technology. Female students, in particular, seem to be increasingly socialized in today's knowledge-driven economy to feel more comfortable studying calculus through technological means. This might have lessened the obstacles professed by females in calculus teaching and learning (Awofala, Lawal, Isiakpere, Arigbabu & Fatade, 2020). Females seemed to be more involved in calculus where technology is used in teaching and learning and this might have reduced the growth of gender variances in attitudes towards Plickers in this study. This result did not corroborate the views of some researchers (Awofala, Olabiyi, Awofala, Arigbabu, Fatade, & Udeani, 2019; Cai, Fan, & Du, 2017) who have found that gender difference exists in attitudes towards technology and males hold more favourable attitude towards technology use than females. This points to only a minimal reduction in the gender attitudinal gap in general (Cai et al., 2017).

6. Conclusion

Two major findings are connected with this study. First, there was a very high attitude toward Plickers among the calculus students. This meant that the calculus students accepted Plickers technology as a learning and assessment tool that could promote their learning of calculus effectively. Second, there was a significant influence of gender on calculus students' attitudes towards Plickers in favour of

females. This meant that there was a gender differential in attitudes towards Plickers in calculus instruction. Females seemed to have benefited more from the use of Plickers during calculus instruction. Three limitations are conceivable in this study. First, this study did not determine the psychometric properties of the ATPCS used to collect primary data except calculating the internal consistency reliability as revealed by Cronbach's alpha. A more robust factor analysis was not carried out, and this could have provided the factorial validity of the scale. Thus, future researchers should endeavor to determine the dimensionality of the scale used to collect data in the present study. Second, this study relied on a survey method which could be deficient in providing more insightful and thoughtful information which might be accomplished when methods such as observations and interviews were used. Third, this study did not investigate the relationship between attitudes towards Plickers in calculus instruction and students' performance in calculus. Future researchers should probe into this. In conclusion, this study has shown the need to integrate Plickers in calculus instruction to make calculus teaching more friendly and fun.

References

Agbatogun, A. (2014). Developing learners' second language communicative competence through active learning: Clickers or communicative approach? *Educational Technology & Society, 17*(2), 257-269.

Anokye-Poku, D. & Ampadu, E. (2020). Gender differences in attitudes and achievement in mathematics among Ghanaian JHS Students. *International Journal of Education, 12*(3), 84-95.

Aricò, F. R., & Lancaster, S. J. (2018). Facilitating active learning and enhancing student self-assessment skills. *International Review of Economics Education*, *29*(June), 6–13. https://doi.org/10.1016/j.iree.2018.06.002.

Arigbabu, A. A. & Awofala, A. O. (2023). General and contemporary teaching methods. In A. A. Rasheed, P. A. Okebukola & R. A. Rufa'i (Eds.), Fundamentals of education book 1 (chapter 23, pg. 637-676). Sterling publishers.

Awofala, A. O. A. & Anyikwa, B. E. (2014). Assessing adult learners' numeracy as related to gender and performance in arithmetic. *New Approaches in Educational Research* 3(2), 83-92.

Awofala, A. O. A. & Lawal, R. F. (2022). The relationship between critical thinking skills and quantitative reasoning among junior secondary school students in Nigeria. *Jurnal Pendidikan Matematika (Kudus), 5*(1), 1-16.

Awofala, A. O. A. & Odogwu, H. N. (2017). Assessing preservice teachers' mathematics cognitive failures as related to mathematics anxiety and performance in undergraduate calculus. *Acta Didactica Napocensia, 10*(2), 81 – 97.

Awofala, A. O. A. (2016). Examining preservice mathematics teachers' attitudes toward mathematics. *Nigerian Journal of Curriculum Studies*, *23*, 292-300.

Awofala, A. O. A. (2017). Assessing senior secondary school students' mathematical proficiency as related to gender and performance in mathematics in Nigeria. *International Journal of Research in Education and Science*, *3*(2), 488-502.

Awofala, A. O. A., Arigbabu, A. A. & Awofala, A. A. (2013). Effects of framing and team assisted individualised instructional strategies on senior secondary school students' attitudes toward mathematics. *Acta Didactica Napocensia, 6*(1), 1 – 22.

Awofala, A. O. A., Lawal, R. F., Isiakpere, B. J., Arigbabu, A. A., & Fatade, A. O. (2020). COVID-19 Pandemic in Nigeria and attitudes towards mathematics homeschooling among pre-tertiary students. *Nigerian Online Journal of Educational Sciences and Technology, 1*(2), 57-70.

Awofala, A. O. A., Ojo, O. T., Okunuga, R. O., Babajide, V. F. T., Olabiyi, O. S., & Adenle, S. O. (2019). Investigating perception of the 21st century skills among Nigerian pre-service science, technology and mathematics teachers, *International Online Journal of Educational Sciences*, *11*(5), 1-12.

Awofala, A. O. A., Olabiyi, O. S., Awofala, A. A., Arigbabu, A. A. Fatade, A. O. & Udeani, U. N. (2019). Attitudes toward computer, computer anxiety and gender as determinants of pre-service science, technology, and mathematics teachers' computer self-efficacy. *Digital Education Review*, *36*, 51-67.

Awofala, A. O. A., Olaguro, M., Fatade, A. O., & Arigbabu, A. A. (2024). Learning engagement as a predictor of performance in mathematics among Nigerian senior secondary school students. *International Journal of Innovation in Science and Mathematics Education, 32*(3), 40-51.

Babacan, N., & Güler, Ç. (2022). The effects of Plickers on English vocabulary achievement, motivation and anxiety. *The Asian Institute of Research Education Quarterly Reviews, 5*(2), 617-630.

Cai, Z., Fan, X., & Du, J. (2017). Gender and attitudes toward technology use: A meta-analysis. *Computers & Education, 105*, 1-13. https://doi.org/10.1016/j.compedu.2016.11.003.

Chng, L., & Gurvitch, R. (2018). Using Plickers as an assessment tool in health and physical education settings. *Journal of Physical Education, Recreation & Dance*, *89*(2), 19–25. https://doi.org/10.1080/07303084.2017.1404510

Chou, P-N. (2022). Using Plickers to support student learning in rural schools: A comprehensive analysis. SAGE Open : 1–11. DOI: 10.1177/21582440221116109.

Efa, Y., & Frimpong, S. A. (2023). Effect of gender on senior high school students' performance and perception of core mathematics in the Cape Coast metropolis of Ghana. *African Journal of Educational Studies in Mathematics and Sciences, 19*(1), 45-73.

Elmahdi, I., Abdulghani, A.-H., & Fawzi, H. (2018). Using technology for formative assessment to improve students' learning. *TOJET Turkish Online Journal of Educational Technology*, *17*(2), 182–188.

Hassan, F. A., & Hashim, H. (2021). The use of an interactive online tool (Plickers) in learning vocabulary among young learners in ESL setting. *Creative Education, 12,* 780-796. https://doi.org/10.4236/ce.2021.124055.

Howell, D. D., Tseng, D. C. & Colorado-Resa, J. T. (2017). Fast assessments with digital tools using multiple-choice questions. *College Teaching*, *65*(3), 145-147.

Kay, R. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education*, *53*(3), 819–827. https://doi.org/10.1016/j.compedu.2009.05.001

Ma, S., Steger, D. G., Doolittle, P. E., & Stewart, A. C. (2018). Improved academic performance and student perceptions of learning through use of a cell phone-based personal response system. *Journal of Food Science Education*, *17*(1), 27–32. https://doi.org/10.1111/1541-4329.12131

Masita, M. & Fitri, N. (2020). The use of Plickers for formative assessment of vocabulary mastery. *Ethical Lingua, 7*(2), 311-320.

McCargo, M. G. (2017). *The effects of Plickers as response cards on academic engagement behavior in high school students* (Master's theses). The University of Southern Mississippi, Hattiesburg, MS. Retrieved from http://aquila.usm.edu/masters_theses%0Ahttp://aquila.usm.edu/masters_theses/300

Mshayisa, V. V. (2020). Students' perceptions of Plickers and crossword puzzles in undergraduate studies. *Journal of Food Science Education, 19,* 49–58.

Nunes, P. S., Catarino, P., Martins, P., & Nascimento, M. M. (2023). Plickers to support similarities learning: An experience on 7th grade Portuguese basic education. *Contemporary Educational Technology, 15*(3), ep436. https://doi.org/10.30935/cedtech/13276

Ogunleye, A., Awofala, A. O. A & Adekoya, E. A. (2014). Effect of students' background knowledge of mathematics on senior secondary school students' achievement in physics. *Chemistry: Bulgarian Journal of Science Education*, 23(6), 863-880.

Okunuga, R. O., Awofala, A. O. A. & Osarenren, U. (2020). Critical thinking acquisition of senior secondary school science students in Lagos state, Nigeria: A predictor of academic achievement. *Journal of Curriculum and Instruction, 13*(1), 44-56.

Pebriantik, E., & Siswantara, E. (2023). University students' perception about Plickers for online formative assessment tools. *Linguistics and English Language Teaching Journal, 11*(2), 138-144.

Ruisoto, P., & Juanes, J. A. (2019). Fostering student's engagement and active learning in neuroscience education. *Journal of Medical Systems*, *43*(3), 66. https://doi.org/10.1007/s10916-019-1192-x.

Wilkins, J. L., Bowen, B. D., & Mullins, S. B. (2021). First mathematics course in college and graduating in engineering: Dispelling the myth that beginning in higher-level mathematics courses is always a good thing. *Journal of Engineering Education, 110*(3), 616-635.

Wood, T. A., Brown, K., & Grayson, J. M. (2017). *Faculty and student perceptions of Plickers. American Society for Engineering Education Zone II Conference, 1–7*. Retrieved from http://zone2.asee.org/sessions/program/3/84.pdf.

Authors

Adeneye O. A AWOFALA, Kampala International University, Kampala, (Uganda). E-mail: awofala.adeneye@kiu.ac.ug

Modiu K. OLAGURO, University of Lagos, Akoka, (Nigeria). E-mail: molaguro@unilag.edu.ng

Samuel A. OLAOLUWA, Oyo State College of Education, Lanlate, (Nigeria). E-mail: luwasa@oyscoel.edg

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