Effects of Computer-Mediated Instruction (Cmi) on Student-Teachers' Misconceptions and Achievement in Physics

Onyukwu Chima Onyedineke
Principal Lecturer, Physics Department
Federal College of Education, Obudu – Nigeria

Mangut Mankilik
Professor of Physics Education, Department of Science & Technology Education, University of Jos – Nigeria

Abstract: Physics is one of the natural sciences taught in Colleges of Education in Nigeria as a teaching subject with course units in line with the branches of physics, such as mechanics, thermodynamics, electromagnetism, optics, acoustics, astronomy and electronics. These course units are generally taught using the traditional lecture approach which neither give students opportunity to participate actively in the learning process nor co-construct knowledge as required in a science classroom. Consequently, students struggle with misconceptions which lead to poor academic achievement in physics. This study investigated the effects of computer-mediated instruction (CMI) on physics student-teachers' misconceptions and achievement in Federal Colleges of Education, South-South Zone, Nigeria. The study adopted pretest-posttest one control group quasi-experimental design with intact classes. The study population comprised 51 physics student-teachers from the three federal colleges of education in the South-South zone of Nigeria who registered for Mechanics and Properties of Matter II during the 2018/2019 academic session. Simple random sampling technique was use to select the two federal colleges of education that participated in the study. Data were collected using Mechanics and Properties of Matter Misconceptions and Achievement Test (MPMMAT). Descriptive and inferential statistics were used for analysis with the assistance of Statistical Package for Social Sciences (SPSS) version 23.0 software. Result findings showed that Physics students hold a number of misconceptions on Mechanics and Properties of Matter II. Results equally revealed that CMI can improve students' achievement in Mechanics and Properties of Matter II and can also reduce their misconceptions in the course. The study concluded that computer-mediated instruction (CMI) is an effective teaching approach which can reduce physics student-teachers' misconceptions in mechanics and improve their academic achievement.

Keywords: Computer-mediated instruction, student-teachers, misconceptions, academic achievement, physics

Introduction

Physics is one of the natural sciences taught at both secondary and tertiary institutions of learning in Nigeria. The objectives of physics education include: to provide students with broad understanding of physical principles of the universe; to help the students develop critical thinking and quantitative reasoning skills; to empower students to think creatively and critical about scientific problems and experiments; and to equip students with the technical know-how required to use science resources effectively.

As a field of study, physics deals with the interaction of matter and energy. The relevance of physics teaching and learning in schools can be viewed from economic, political and societal contexts. This is evident in physics research contributions which have led to the development of knowledge and skills in technological designs, information technology, space colonization and renewable energy technologies. Today, we can boost of electronic banking, electronic commerce, electronic governance and internet services because transistors were developed to build computers

that facilitate their operations (Smith & Anderson, 2016).

At the colleges of education in Nigeria, students combine physics with other teaching subjects such as Physics/Mathematics, Physics/Computer Science Education, Physics/Integrated Science, and Physics/Chemistry. To all the students who opted for any of the above physics course combinations, Mechanics and Properties of Matter I and II are compulsory courses for them during their first and second year in the college. The objective of the course is to provide students with the broad understanding of physical principles of the universe; such that they can identify and explain the basic concepts in mechanics and properties of matter, which is essential in the understanding of other aspects of physics (Federal Republic of Nigeria (FRN), 2012). Like other science courses taught at colleges of education, lecturers teaching Mechanics and Properties of Matter I and II are at liberty to deliver their lessons using any of following teaching methods - traditional lecture method, mind-mapping method, demonstration method, field trips/excursion, discussion, workshop, computer-assisted learning, project/ problem-based teaching method and game/stimulation (Deslauriers, Schelew, & Wieman, 2011; Adekoya & Olatoye, 2011; FRN, 2012; McCabe, 2014; Eze & Osuyi, 2018; Jushua, 2019; Okotubu, 2020). Of all these instructional methods, traditional lecture method is commonly used currently by lecturers teaching physics at Nigeria colleges of education perhaps due to tightened financial budgets of the colleges (Smith & Valentine, 2012; Goffe & Kauper, 2014). But, this does not seem to have yielded the expected results such as addressing misconceptions and poor achievement in physics among student-teachers.

The traditional lecture method of teaching physics is teacher-centred as well as information-centred in nature. Hence, the lecturer is considered a sole-resource with the monopoly of knowledge in classroom instruction, while the students are passive recipients of information. Consequently in mechanics classroom sessions, lecturers start lecturing on the basic principles of mechanics from which they derive mathematical models (Antwi, 2013). Thereafter, they present illustrative applications of the models with practice questions to test the students' ability to replicate them during the periodic classroom assessments and final examinations. This approach does not allow students' active participation in the learning process, which is against the spirit of development of scientific attitude and training in scientific methods. The traditional lecture method is averse to activity-based learning which offers students opportunity to address real life problems using applied knowledge (Ganyaupfu, 2013). It equally does not give students opportunity to discover and correct any misconception they hold in physics as well as interact with one another (Chaudhury, 2011). Okotubu (2020), noted that traditional lecture method has less significant effect on students' achievement in mechanics when compared with teacher-student interactive method.

However, deployment of modern information and communication technology in pedagogical processes has promoted enhanced learning environment with greater classroom engagement as well as supports for collaborative learning among students (Chuang, 2014), than the conventional lecture approach could provide. Computer-mediated instruction (CMI) is one of such modern information and communication technology driven instructional approach; its use in teaching and learning process has positive effect on the academic achievement of students (Ernest, 2015; Gungaden, 2015). Though, it has been argued from research perspective that, the use of technology without due consideration to its design, implementation and teacher factors can hardly improve students' academic achievement (Raines & Clark, 2011; Cheung & Slavin, 2013).

Statement of the Problem

Many physics students in Colleges of Education come into their classes with certain misconceptions or 'alternative frameworks' (Kuczmann, 2017), resulting from incorrect past instructional methods (mainly lecture method) and often times from their past experiences. For instance, many physics students believe that for a body to be sustained in its motion there must be a continuous application of force on it. Besides, the

Newton's (1687) first and second laws of motion (Live Science, 2017) state that, a net force (unbalanced force) causes acceleration which is in the same direction as the net force. The abysmal achievement of students in physics could be related to the misconceptions they have about the course (Mesutoglu & Birgili, 2017). Studies showed that proactive teaching approaches such as computer-mediated instruction have effects on students' achievement in physics (Suleman, Hussain, Din, & Iqbal, 2017; Adolphus, & Omeodu, 2020). However, there are problems of misconceptions caused by using the traditional lecture method alone in teaching physics courses at Colleges of Education and this needs to be critically dealt with in order to minimize or totally reduce students' misconceptions about physics concepts. It is in the light of the above that the study specifically investigated the effects of computer-mediated instruction on physics students' misconceptions and achievement in Federal Colleges of Education South-South zone, Nigeria.

Objectives of the Study

The study specifically attempted to address the following objectives;

1. Ascertain student-teachers' misconceptions on Mechanics and Properties of Matter.
2. Determine the achievement mean scores of the experimental group in Mechanics and Properties of Matter before and after exposure to computer-mediated instruction method.
3. Find out the effect of computer-mediated instruction method on the misconceptions mean scores of the experimental group.

Research Questions

The following research questions were used for the study;

1. What are the identified physics student-teachers' misconceptions in Mechanics and Properties of Matter before and after exposure to treatment?
2. What is the difference between the pre-test and post-test achievement mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test?
3. What is the difference between the pre-test and post-test misconceptions mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test?

Hypotheses

Ho1: There is no significant difference between the pre-test and post-test achievement mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test.

Ho2: There is no significant difference between the pre-test and post-test misconceptions mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test.

Methodology

The study adopted the pre-test post-test quasi-experimental non-equivalent control group research design with intact classes. The study population comprised 51 second year physics combination student-teachers who registered for PHY 213 – Mechanics and Properties of Matter II during the 2018/2019 academic session at federal colleges of education in the South-South geopolitical zone of Nigeria. The zone has three federal colleges of education with one college each situated at Delta State, Cross River State and River State respectively. The study sample comprised 41 participants who were drawn from two intact classes of Year II student-teachers with different physics course combinations from two (College A = 13 participants and College B = 28 participants) out of the three Federal Colleges of Education (Colleges A, B and C) in the South-South geo-political zone of Nigeria. There was no sampling of the students because of the nature of quasi-experimental design which prescribes the use of intact classes. However, the two federal colleges of education used for study were randomly selected through simple random sampling technique. The two institutions were assigned to experimental and control groups respectively.

Data were collected using Mechanics and Properties of Matter Misconceptions and Achievement Test (MPMMAT). The instrument was developed by the researcher and it consists of sixty (60) two-dimensional confidence test (TDT) items. MPMMAT had content and construct validities as well as a

reliability coefficient of 0.97, **p** < 0.01 obtained through test-retest method. Analysis of data was done using inferential (t-test) and descriptive (percentages, mean and standard deviation) statistics with the help of the Statistical Package for Social Sciences (SPSS) version 23.0 software. The hypotheses were tested at 5% level of significance (P< 0.05) with n-1 degree of freedom.

Results and Discussion

Table 1: Effect of Computer-mediated Instruction on the Experimental Group's Misconceptions in Mechanics and Properties of Matter Misconceptions and Achievement Test (MPMMAT)

Test Item Serial Number and Identified Misconceptions	Pre-Test N = 28				Post-Test N=28			
	Participants with Misconceptions		Participants without Misconceptions		Participants with Misconceptions		Participants without Misconceptions	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
(1) Fluids cannot be subjected to shear forces.	16	57%	12	43%	6	21.43%	22	78.57%
(2) Surface tension is a function of the curvature of the interface.	20	71.43%	8	28.57%	5	17.86%	23	82.14%
(4) Spherical nature of raindrops is due to atmospheric pressure.	16	57.00%	12	43.00%	11	39.29%	17	60.71%
(29) Surface tension is the same as the coefficient of surface tension.	12	42.86%	16	57.17%	6	21.43%	22	78.57%
(33) Surface tension of liquids is sustained at critical temperature	18	64.29%	10	35.71%	8	28.57%	20	71.43%
(38) Steady flow has identical velocity vector at every instant.	17	60.71%	11	39.29%	9	32.14%	19	67.86%
(40) Objects at rest will always remain at rest.	19	67.86%	9	32.14%	8	28.57%	20	71.43%
(42) Velocity of falling objects varies directly with time of landing.	12	42.86%	16	28.57%	5	17.86%	23	82.14%
(47) Net force on a body causes the body's motion.	10	35.71%	18	64.29%	6	21.43%	22	78.57%
(48) Object's momentum accounts for resistance to change in its motion.	18	64.29%	10	35.71%	8	28.57%	20	71.43%
(52) Acceleration due to gravity decreases with object's weight.	15	53.57%	13	46.43%	7	25%	21	75%
(53) Gravitational force exerted by the sun causes the acceleration of the moon.	19	67.86%	9	32.14%	10	35.71%	18	64.29%

Research question one: "What are the identified physics student-teachers' misconceptions in Mechanics and Properties of Matter before and after exposure to treatment?"

As can be seen, physics student-teachers' misconceptions on Mechanics and Properties of Matter and the effect of computer-

mediated instruction (CMI) is reported in Table 1. Findings showed that there are twelve misconceptions prevalent among the participants before and after exposure to computer-mediated instruction. These misconceptions include; 1. 'fluids cannot be subjected to shear force'. 2. 'surface tension is a function of the curvature of the interface'. 3. 'spherical nature of raindrops is due to atmospheric pressure'. 4. 'surface tension is the same as the coefficient of surface tension'. 5. 'surface tension of liquids is sustained at critical temperature'. 6. 'steady flow has identical velocity vector at every instant'. 7. 'objects at rest will always remain at rest'. 8. 'Velocity of failing objects varies directly with the time of landing'. 9. 'net force on a body causes the body's motion'. 10. 'object's momentum accounts for resistance to change in its motion'. 11. 'acceleration decreases with object's weight'. 12. 'gravitational exerted on sun causes the acceleration of the moon in its elliptic orbit'. Results therefore, indicated that the student-teachers come to physics classroom with some misconceptions which agrees with the assertion that physics students come to mechanics class with a number of misconceptions (Antwi, 2013).

Findings further revealed that 57% of the participants were of the view that "fluids cannot be subjected to shear forces" before the treatment after which only 21.43% of the participants still hold the same view. In another case, 71.43% of the participants claimed that "Surface tension is a function of the curvature of the interface" but after the treatment only 17.86% of the participants still held onto such misconception. Findings showed that there was reduction in the percentage of participants with misconceptions across the other ten cases after exposure to computer-mediated instruction, indicating that students' misconceptions in physics cannot be completely eradicated. This result agrees with the findings of previous studies which concluded that students' misconceptions are persistent and resistant to change (Ozgur, 2013; Gurel, Eryilmaz & McDermoth, 2015).

Research question two: "What is the difference between the pre-test and post-test achievement mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test?

Table 2: The Results of Comparison of Achievement between the Experimental Group's Pre-test and Post-test Scores in Mechanics and Properties of Matter Misconceptions and Achievement Test

Group (Experimental)	N	Minimum	Maximum	Mean	Mean Diff.	Standard Deviation
Pre-test	28	25%	65%	46.46%		10.11
					12.86%	
Post-test	28	45%	75%	59.32%		8.38

As revealed in Table 2, the participants' minimum and maximum scores in MPMMAT increased from 25- 45% and 65-75% respectively with a mean score of 59.32% after treatment was administered. This is an indication that the participants did better in the post-test than in the pre-test with 12.86% mean score difference. The results is in tandem with the findings of Onah, Ugwuanyi, Okeke, et al. (2020), which concluded that the effective use of computer-mediated instruction (CMI) increases students' achievement in mathematics and physics.

Research question three: What is the difference between the pre-test and post-test misconceptions mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test?

Table 3: The Results of Comparison of Pre-test and Post-test Misconceptions of the Experimental Group in Mechanics and Properties of

Matter Misconceptions and Achievement Test

Group Experimental	N	Minimum	Maximum	Mean	Mean Difference	Standard Deviation
Pre-test	28	28%	48%	37.61%	18.68%	5.62
Post-test	28	38%	68%	56.29%		7.90

The results showed that the experimental group had higher misconceptions mean score (56.26%) in the post-test than in the pre-test (37.61%) with a mean score difference of 18.65 in MPMMAT. In terms of spread, the results in Table 3 show that the participants' misconceptions mean scores in MPMMAT spread farther around the mean score during the post-test (SD = 7.90) than in the pre-test (SD = 5.62), which suggested that the participants had less misconceptions after exposure to computer-mediated instruction. Misconceptions are capable of hampering participants' coherent knowledge construction and its reduction fostered the participants' improved achievement in MPMMAT. This findings agreed with the findings reported in Badenhorst, Hartman and Mamede (2016) as well as Mesutoglu and Birgili (2017), which concluded that misconceptions can impact on students' learning process, hamper their coherent knowledge construction and play obstructive role when students' are required to perform complex cognitive tasks.

Hypothesis One: There is no significant difference between the pre-test and post-test achievement mean scores of the experimental group in Mechanics Properties Matter Misconceptions and Achievement Test.

Table 4: The Results of Comparison of Achievement between the Experimental Groups' Pre-test and Post-test Mean Scores in Mechanics and Properties of Matter Misconceptions and Achievement Test using t-test for Independent Samples

Test	N	Mean $\bar{x}$	S.D	t_{cal} (α= 0.05)	Df	P-value	Decision
Pre-test	28	46.46%	10.11				
				-5.182	54	0.163	Accepted
Post-test	28	59.32%	8.38				

F = 1.456, P > -5.182
 not significant

Table 4 shows that the experimental group had a pre-test mean score of 46.46% and a post-test mean score which stood at 59.32% with standard deviation of 10.11 and 8.38 respectively in the MPMMAT. The results equally reveal that at α = 0.05 level of significance with degree of freedom Df = 54, the calculated t-value (-5.182) is less than the P-value (0.163), hence the null hypothesis was retained. It was therefore concluded that there is no statistical significant difference between the pre-test and post-test achievement mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test. This is despite the fact that the experimental group had improved achievement mean score during the post-test. The findings is tandem with previous studies' results, which concluded that computer-mediated instruction technique produces

achievement gain score effect on the experimental group (Tambade & Wagh, 2011; Bennett, 2012).

Hypothesis Two: There is no significant difference between the pre-test and post-test misconceptions mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test.

Table 5: The Results of t-test Analysis of the Difference between the Experimental Groups' Pre-test and Post-test Misconceptions Mean Scores in Mechanics and Properties of Matter Misconceptions and Achievement Test

Test	N	Mean $\overline{x}$	S.D	t_{cal} (α= 0.05)	Df	P-value	Decision
Pre-test	28	37.61	5.62				
				-10.195	54	0.038	Accepted
Post-test	28	56.29	7.90				

F = 1.976, P > -10.195
                              not significant

The results in Table 5 revealed that the calculated t-value (-10.195) is less than the P-value (0.038) at α = 0.05 with the degree of freedom Df = 54, hence the null hypothesis was retained. It was then concluded that, there is no significant difference between the pre-test and post-test misconceptions mean scores of the experimental group in Mechanics and Properties of Matter Misconceptions and Achievement Test. This does not indicate non variance in the participants' misconceptions mean scores before and after treatment administration. Whatever the marginal difference may be, it is predicated on the treatment effects. The findings is in consonant with the result of previous study which concluded that computer-mediated instruction method assists in increasing students' achievement in science related courses (Serin, 2011).

Conclusion

The study revealed that physics student-teachers at tertiary institutions have misconceptions on Mechanics and Properties of Matter, which negatively impacts on their achievement in the course. The results further showed that the use of computer-mediated instruction (CMI) can help reduce physics student-teachers' misconceptions and improve their achievement in Mechanics and Properties of Matter. The implication is that, CMI can be employed effectively in any physics course to address students' misconceptions and achievement problems.

Recommendation

Based on the findings of the study, the following specific recommendations are made towards remedying misconceptions and improve achievement in Mechanics and Properties of Matter among physics student-teachers in federal colleges of education.

1. Physics lecturers should diagnose their students' previous knowledge through in-depth interview on related concepts to any topic they intend to teach, so as to address their misconceptions prior to and while lesson progresses.
2. Physics lecturers should effectively utilize computer-mediated instruction approach in correcting students' misconceptions and enhancing their academic achievements in physics courses.
3. The College Managements in synergy with the relevant government agencies should provide adequate personal computers to physics student-teachers as part of their training facilities.
4. The College Managements should train and retrain physics lecturers in the area of computer-simulated courseware development and utilization on regular basis through opportunities offered in the Tertiary Education Trust Fund (TETFund) academic staff capacity-building sponsored workshops. This will foster

technologically enriched learning environment that will enhance students' achievement in physics courses.

5. Physics student-teachers should be given opportunities to relate physics concepts learnt in the classroom to their everyday life to avoid possible misconceptions.

6. Urgent efforts should be made by physics lecturers and authors of physics textbooks to address the menace of school-made misconceptions; through the use of appropriate pedagogical strategies and withdrawal of faulty textbooks from circulation.

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