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Computer-assisted instruction, project based learning and achievement of Deaf learners in Biology

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Abstract

Deprivation of language abilities has negative influence on academic achievement of deaf learners especially in biology. Although, previous studies have underscored teaching approaches as a factor that influence participation and low achievement in biology but little or no studies exist to determine the effects of computer and project based learning approaches on the achievement of deaf learners in Biology. Therefore, this study determined the effect of computer-assisted instructions (CAI) and project based learning (PBL) on the achievement of deaf learners in Biology in Ibadan, Nigeria. The study engaged the pretest-posttest, control group quasi experimental research design. Purposive sampling technique was used to select deaf learners from three secondary schools in Ibadan, Nigeria. The participants were randomly assigned to two treatment groups: CAI, PBL and control group. Treatment lasted 8 weeks. Biology Achievement Test and Achievement Motivation Scale were used for data collection. Data were analysed using Analysis of covariance at 0.05 level of significance. Results showed a significant main effect of treatment of achievement in Biology among deaf learners ($F(2,28) = 11.432$, $\eta 2 = 0.574$). Participants exposed to CAI obtained the highest mean score of 13.74 followed by PBL group (10.51) and control group (9.15). There was also a 3-way interaction effect on deaf learners' achievement in biology. CAI was more effective in enhancing achievement in Biology among deaf learners the PBL. Therefore, Biology teachers to deaf learners should adopt CAI and perhaps PBL to motivate and stimulate deaf leaners' interest in life sciences.

KEYWORDS: Computer-assisted instruction, project based learning, deaf learners, biology, achievement in biology

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1. Introduction

Language deprivation and associated psycho-social factors can be identified as a factor that influences unequivocal science achievement of deaf learners when compared with their colleagues without hearing deficit. The poor performance of deaf learners in Biology and other science subjects in various examinations is worrisome to teachers, parents and other relevant stakeholders who are interested in the education of high school learners as a means to achieving the sustainable development goals. Yusuf and Afolabi (2010) and Umar, Fugu and Aliyu (2018) mention poor performance in Biology among high school learners, with no report of performance of deaf learners. However, it may be assumed that achievement in Biology among deaf learners will be lower than their hearing counterparts largely because deaf learners experience communication difficulties and lack access to incidental learning about nature and natural resources, ecosystem, human development and dynamics which are often presented verbally in classroom. Hence, due to teaching strategies which do not take cognizance of communication difficulties, deaf learners seem to have less interest in actively participating in scientific instructions. Thus, deaf learners are disconnected from life science subjects with elevated impaired self-efficacy and less motivation to studying life sciences.

Although it is expected that teachers of deaf learners and sign language interpreters should fill the gap in students' knowledge and use appropriate signs to pass on scientific instructions in the classroom. However, informal observation and discussions with science teachers in deaf schools in Nigeria revealed that such

effort is yet to yield the desired results. Flores and Rumjanek (2015) aver that science teachers and interpreters in deaf schools find it difficult to express some biological concepts in other science-related subjects effectively using sign languages because they lack the required skills to effectively explain concepts to the students; hence, the performance of deaf learners in Biology may not be encouraging. Ugwuadu (2017) discuss the achievement of learners who sat for the Senior School Certificate Examination in Biology between 2012 and 2017. Similarly, Aidoo, Boateng, Kissi and Ofori (2016) note that there has been a significant trend in South Africa students' failure in physical sciences in the National Senior Certificate (NSC) final examination. However, the reports of Aidoo, Boateng, Kissi and Ofori (2016) and Ugwuadu (2017) do not present or take into consideration the performance of deaf learners in those examinations. This is perhaps because the population of deaf learners is low compared to their hearing counterparts. Gallaudet Research Institute (2004), Huber and Kipman (2012), Ataabadi, Yusefi and Moradi (2014) have shown that deaf learners perform weakly in the chain of numbers, vocabulary comprehension, scientific knowledge and reasoning. They lack experience with scientific reasoning and the mental models as well as ability to integrate new scientific facts. The findings mentioned above raises serious concerns about the academic achievement of the deaf in the science classrooms, their subsequent transition to tertiary institutions, workplace and family life.

Sangodoyin's (2011) research on teaching of scientific concepts found that inadequacy of resources for teaching, teachers' unsatisfactory use of resources and unsatisfactory performance in practical and field work were some of the factors militating against effective learning outcomes in Biology. Poor teaching method was observed by Ige (1998) as one of the causes of students' dismal performance in Biology. Therefore, Ige (1998) asserts that the conventional teaching strategy, which involves the sign/chalk-talk principles, is not suitable for teaching science-related concepts to deaf learners. Although the conventional method of teaching may be effective for efficiently disseminating a large body of content to a large number of students without hearing impairment, Aremu and Sangodoyin (2011) state that the one-way exchanges often promote passive and fail to stimulate student's motivation, confidence and enthusiasm. Teaching deaf learners require a series of influential teaching approaches in ways that promote meaningful learning, project solving, and critical thinking. When classrooms of the deaf are not stimulated and enriched with facilities and effective instructional techniques that could compensate for the loss in the sense of hearing, the academic achievement of such students tends to drop to a level that is worrisome to the student, parents, teachers and other stakeholders. In other words, the conventional teaching strategy (chalk-talk/sign) may present additional challenges to the teaching-learning process of deaf learners; thus, such non-technological pedagogic strategy may not be suitable for teaching basic digestive systems to deaf learners.

Kareem (2015) indicated that there is "an increase in the proportion of educators utilizing technology to enhance academic instructions with a proven record of success and effective teacher-students relationship as well as learning outcomes". Though, Kareem (2015) further noted that that technology in the classroom can be useful for teaching and learning enhancement as well as in pedagogical management but application and implication of technology in scientific or academic instruction for deaf learners in Nigeria particularly in Ibadan is yet to be well established in previous studies. Based on the foregoing, it is evident that there is a dire need to stimulate scientific teaching and learning with technology-based instructional strategies for deaf learners. This is because the power of technology in education is capable of removing constraints and enabling computer applications to provide learning support for deaf learners. Over the years, computer applications have found their way into the classroom to assist in the teaching and learning process as an instructional package known as Computer-Assisted Instruction (CAI). This is an instruction or remediation presented on a computer to illustrate a concept through attractive animation, sound, and demonstration. It can be referred to as a self-learning technique usually offline/online, involving interaction of students with programmed instructional materials. It is an interactive instructional technique in which a computer is used to present the instructional material and monitor the learning that takes place. It uses a combination of text, graphic sound and video in enhancing the learning process (Yenice, 2006).

According to Alessi and Trollip (2001), CAI packages are of five different types, which are the tutorial, simulation, educational games, drill and practice, and hypermedia modes. The tutorial mode of the CAI allows learners to receive immediate feedback to the questions and prompts. The tutorial mode of CAI is a learner-centred strategy that tests learners' mastery of subject contents from a simple to a more complex academic task (Özmen, 2008). Past studies that used the tutorial mode of CAI identified diverse effects of the computer package on students' learning outcomes. For example, Okoro and Etukudo (2001) applied CAI in teaching Chemistry; Egunjobi (2002) applied it in teaching Geography and Yusuf and Afolabi (2010) in teaching Ecology. They all confirmed that CAI is more effective in enhancing students' performance in other

subjects than the conventional classroom instruction. However, none of these studies was conducted among deaf learners. Therefore, this study determined the effect of the tutorial mode of CAI on the achievement of deaf learners in Biology.

Project based Learning (PBL) is an instructional strategy currently gaining popularity in the field of science education. It is a product of recent advances in cognitive science and the new philosophy of science. It is a learner-centred approach that gives students opportunity to design and engage in scientific instructional activities that bring learners more closely to their true world (Thomas, 1999). For deaf learners, PBL facilitates an intimate connection and interaction with the natural world. In other words, deaf learners may experience natural integration with the ecosystem or the world around them. It is an instructional method that helps students to use the open-inquiry approach in learning to apply scientific knowledge in real-life situations (Ketpichainarong, Panijpan & Ruenwongsa, 2010), unlike the conventional method, in which students become passive in the teaching process, that does not promote project-solving and cognitive skills (Ronis, 2008).

The PBL involves an experimental learning process that is composed of data collection, investigation, observations, explanations and drawing conclusions (Bell, 2010). In some studies, PBL was found to have contributed positively to students' academic achievement (Cengizhan, 2007; Kanter & Konstantopoulos, 2010), meaningful learning in science modules (Kanter, 2010), students' individual learning (Chang & Tseng, 2011) and attitude towards science modules (Tortop & Özek, 2013). AltunYalçın, Turgut and Büyükkasap (2009), employed a quasi-experimental non-equivalent pretest-posttest research design and found significant differences in students' attitude toward physics, electricity achievement and scientific process skills between learners exposed to PBL and the control group. The finding of AltunYalçın, Turgut and Büyükkasap (2009) also support the idea that irrespective of gender, PBL improved the students' learning and enhances positive attitudes towards physics.

Gender issues in achievement of learners in sciences remain critical. Although research has consistently investigated the moderating effect of gender on students' engagements and achievement in scientific instructions, reports from various studies still remain largely inconclusive (Isa, 2005; Ekwueme & Umoinyang, 2005), while the influence of gender on achievement of deaf learners in Biology is yet to receive the needed research attention. Ifeako (2005) and Obeka (2007) reported that male students had higher achievements and interest scores in Chemistry than females. This was attributed to sex-role stereotyping, masculine image of science and female socialization process. Contrary to the findings of Obeka (2007), Ekwueme and Umoinyang (2005) reported that gender influenced achievement in favour of females, while Danmole and Femi-Adeoye (2004) found no significant difference in the achievement of students due to gender. It is based on this premise that this study examined the influence of gender on achievement in Biology among deaf learners.

Researchers, such as Yazdani and Godbole (2014) and Roy (2015), have noted that, irrespective of gender, achievement motivation is a critical factor that impacts science achievement. Although the submissions of Yazdani and Godbole (2014) and Roy (2015) were based on research experience among learners without disabilities, the finding motivated this study to examine the moderating role of achievement motivation among deaf learners. Generally, achievement motivation is expectancy of finding satisfaction in mastery of different and challenging performance (Roy 2015). Individuals with a greater degree of achievement motive are found to have a peculiar level of aspiration, while those with a lower degree of achievement motive will either not like to take any task in hand or will choose the simplest and easiest task or will choose the most difficult task where there is no chance for success. This implies that a learner whose achievement motive is stronger is more motivated to achieve, tries to maximize his own anxiety about failure, struggles hard for getting success and derives maximum pleasure from success (Roy, 2015).

Mahyuddin, Elias and Noordin (2009), Athman and Monroe (2004), Kobbeltvedt (2010) and Chan and Norlizah (2017) found that achievement motivation significantly and positively correlated with academic achievement. Mahyuddin, Elias and Noordin (2009) and kavyakishore (2013) state that learners with high motivation are ready and eager to learn and actively participate in scientific activities. Hence, such learner may have a higher level of achievement and satisfaction in sciences than learners who are less motivated. Individuals with a higher level of motivation display stronger academic self-efficacy and excellence, and are more likely to engage in self-regulating learning (Athman & Monroe, 2004).

Despite the volume of research reports based on the variables of interest in this study (computer-assisted instructions, project-based learning, achievement motivation and gender) on learners' performance in science subjects, there is no established study that considered the implications of computer -assisted and project-based learning instructional strategies for the academic achievement of deaf learners in Biology. Therefore, this study is anchored to the cognitive

learning theory based on Bloom's taxonomy (Bloom et al., 1956), which assumes that there are some mental processes which have association with external environmental factors to influence a learning behaviour via the cognitive, affective and psychomotor domains. The outward exhibition of learning is not paramount to cognitivists; they focus more on mental processes and how learners can link environmental variables with mental images to arrive at meaningful learning experience. In line with the principles of the cognitivists, this study engaged the comprehension, synthesis, decision-making, abstraction, creative thinking, evaluative, analytical and problem-solving skills of deaf learners in the science classroom. This study is informed by the Cognitive Load Theory [CLT] (Sweller, Ayres, & Kalyuga, 2011) which is assumed to be suite situational constrained pedagogical strategies such as class periods which was used in this study. The CLT does not appreciate assumptions of conventional theories of learning, however, it focuses cognitive domains needed for functional working memory and long-term learning experience (Hoffman, Helversen & Rieskamp, 2013). Hence, this study determined the effects of computer-assisted instruction, project-based learning and conventional instructional strategies vis-à-vis the moderating effect achievement motivation and gender on their achievement of deaf learners in Biology.

2. Hypotheses

The following null hypotheses will be tested at 0.05 level of significance:

HO1. There is no significant main effect of treatment on deaf learners' achievement in Biology.

HO2. There is no significant interaction effect of treatment and gender on deaf learners' achievement in Biology.

HO3. There is no significant interaction effect of treatment and achievement motivation on deaf students' achievement in Biology.

HO4. There is no significant interaction effect of treatment, gender and achievement motivation on deaf students' achievement in Biology.

3. Materials and Method

The study adopted the pretest-posttest, control group quasi-experimental research design. A 3x2x2 factorial matrix was employed. It was made up of treatment at two levels (Computer-Assisted Instruction, Project-based Learning) and a control group (Conventional teaching method); these were crossed examined with achievement motivation (high and low) and gender (male and female) of the deaf learners who participated in the study.

The design is represented thus:

Experimental Group 1 (E1): O_1 X_1 O_4

Experimental Group 2 (E2): O_2 X_2 O_5

Control Group 3 (C): O_3 X_3 O_6,

where:

O_1, O_2 and O_3 represent pretest scores of the experimental groups 1 and 2 and the control group, respectively;

O_1, O_5 and O_6 represent posttest scores of experimental groups 1 and 2 and the control group, respectively;

X_1 represents the treatment for experimental group 1 (the tutorial mode of CAI);

X_2 represents the treatment for experimental group 2 (PBL); and

X_3 represents the control group for the conventional method of teaching of Biology.

4. Selection of Participants

The participants for the study were 30 Senior Secondary School II deaf learners who were purposively selected from 3 deaf high schools, represented as Schools A, B and C, in Ibadan, Oyo State, Nigeria. Schools A and C were located within the Ibadan North Local Government Area, while School C was situated at the centre of Ibadan North East Local Government Area. The participants from School A were exposed to the PBL strategy; those from School B to the tutorial mode of CAI; and those from School C were used for the control group –they were exposed to the conventional teaching approach. Ten deaf learners in the Biology classroom from each school were randomly selected through ballot to participate in the study.

5. Research Instruments

The Biology Achievement Test (BAT) was developed by the researcher to test the knowledge of the participants on the digestive system as designed in the Senior Secondary School Curriculum for Biology by the Nigerian Educational Research and Development Council (Federal Ministry of Education, 2009). The achievement test consisted of 40 multiple choice test items with options 'a, b, c and d' which were developed based on the Bloom's taxonomy. Example of the BAT items include: Mechanical digestion of food substances

begins in the _____ (a) large intestine (b) stomach (c) mouth (d) small intestine. The BAT was validated using experts' review and the internal consistency reliability measure, which was calculated using the KR-20 formula. Thirty-one items survived the reliability measure at 0.78 and an average means difficulty value of 0.45. This implies that the test was neither too simple nor too difficult. Only the 30-item BAT was used to determine the pretest and posttest scores of the participants.

The Achievement Motivation Scale (AMS) was adapted from the Githuas' (2002) achievement motivation tool to measure the deaf learners' motivation towards Biology. The 26-item scale which had item like 'I am usually worried when I encounter a difficult problem in Biology that I couldn't understand at once' was designed in a 5-point Likert scale response format of "strongly disagree", "disagree", "undecided", "agree" and "strongly agree". Strong agreement with an item was given a score of 5 and strong disagreement was given a score of 1. The instructional guides (CAI Guide in Biology, PBL Instructional Guide in Biology and Conventional Instructional Guide in Biology) were developed by the author to guide the research assistants on the process of administering the treatment in the various groups. The guides delineate the roles of instructors and learners per time and how they interact with the treatment stimuli. The instructional guides had been earlier subjected to face and content validity through experts' review. The comments, observations, criticisms and suggestions of the experts were taken into consideration to improve the quality of the final instructional guides used for the experimental groups 1 and 2 as well as the control group.

6. Procedure for Data Collection

Approval to conduct the study was given by the University of Zululand from the Research Ethics Committee (UZREC 171110-030). The research obtained a permission to conduct the study in Ibadan from Local Education Authority of the Ibadan North and Ibadan North East Local Government Areas respectively. Both the Ethical approval from the University of Zululand and letter of introduction/permission from the Local Education Authorities to conduct the study in deaf senior secondary deaf schools were presented to the heads of the schools used in this study. Biology teachers from the selected schools were trained for 5 days on the interventions specific to their learners. Based on the training received on how to deploy the instructional guides for the purpose of the study, Biology teachers assisted in administering the BAT, AMS and treatment packages.

All participants were pretested with the BAT and AMS at the first week of intervention. The participants in the two experimental groups (CAI and PBL instructional strategies) were treated for a period of eight (8) weeks. Each treatment session lasted 45 minutes. The participants in the control group (Conventional Method) were given a placebo treatment; they were taken through concepts of the digestive system using the conventional mode of teaching and encouraged to do more on their own. The same instrument used during the pretest was deployed to assess the two treatment groups and the control group. The posttest was conducted on the eighth week of intervention.

7. Data Analysis

The data generated were subjected to statistical analysis using Analysis of Covariance to test the null hypotheses at 0.05 level of significance. Similarly, an estimates marginal mean difference of interventions was determined.

8. Results

HO_1. There is no significant main effect of treatment on deaf learners' achievement in Biology.

Table 1 reveals that there was a significant main effect of treatment on deaf learners' achievement in Biology ($F_{(2,28)} = 11.432$, $p < 0.05$; $\eta^2 = 0.574$). Therefore, the null hypothesis HO_1 was not accepted. This implies that the treatment had a significant main effect on achievement in Biology among the participants.

To further establish and determine the actual source of the observed significant main effect in ANCOVA, an estimated marginal mean difference presented in Table 2 indicated the performance of the participants in all the groups. The direction of decreasing main effect of treatment on the participants' achievement of in Biology is Computer-assisted Instruction, Project-Based Learning and the Control Group, that was on the conventional teaching method. Computer-assisted Instruction was more potent than Project-based Learning among the deaf learners in teaching the concept of the digestive system in Biology.

HO_2. There is no significant interaction effect of treatment and gender on deaf students' achievement in Biology.

Table 1 indicates no significant interaction effect of treatment and gender on the deaf learners' achievement in Biology ($F_{(2,28)} = 1.056$, $p > 0.05$; $\eta^2 = .110$).

Tests of Between-Subjects Effects

Dependent Variable: Post_Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	181.324[a]	12	15.110	5.150	.001	.784
Intercept	106.083	1	106.083	36.158	.000	.680
Pre_achievement	.041	1	.041	.014	.907	.001
Treatment	67.080	2	33.540	11.432	.001	.574
Gender	.505	1	.505	.172	.683	.010
Achievement_motivation	10.003	1	10.003	3.409	.082	.167
Treatment x Gender	6.195	2	3.098	1.056	.370	.110
Treatment x Ach_mot	8.609	2	4.304	1.467	.258	.147
Gender xAchiev_motivation	.474	1	.474	.162	.693	.009
Treatment x Gen x Ach_moti	22.806	2	11.403	3.887	.041	.314
Error	49.876	17	2.934			
Total	4130.000	30				
Corrected Total	231.200	29				

a. R Squared = .784 (Adjusted R Squared = .632)

Table 1 - Analysis of covariance of posttest achievement scores of treatment, gender and achievement motivation

Estimates

Dependent Variable: Post_Achievement

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
CAI	13.736[a]	.699	12.262	15.210
PBL	10.514[a]	.677	9.086	11.942
Conventional	9.146[a]	.688	7.694	10.598

a. Covariates appearing in the model are evaluated at the following values:

Pre_achievement = 8.10.

Table 2 - Estimated Marginal Means

Therefore, the null hypothesis was not rejected. This finding implies that the interaction effects of treatment and gender had no statistically significant effect on achievement on the deaf learners in Biology.

HO_3. There is no significant interaction effect of treatment and achievement motivation on deaf learners' achievement in Biology.

Table 1 also reveals no significant interaction effect of treatment and achievement motivation on the deaf learners' achievement in Biology ($F_{(2,28)}$ = .258, p > 0.05; η^2 = .147). Therefore, the null hypothesis was not rejected. This finding implies that the interaction effects of treatment and achievement motivation had no statistically significant effect on achievement of the deaf learners in Biology.

HO_4. There is no significant interaction effect of treatment, gender and achievement motivation on deaf students' achievement in Biology.

Table 1 indicates that there was a significant interaction effect of treatment, gender and achievement motivation

on the deaf learners' achievement in Biology ($F_{(2,29)}$ = 3.887, $p < 0.05$; $\eta^2 = .314$). Thus, the null hypothesis was not accepted. The estimated marginal means of post-achievement scores across treatment, gender and achievement motivation are presented in Figure 1 and Figure 2.

Figure 1 shows that the female participants had a higher mean score than their male counterparts across the two treatment groups but the male participants scored higher than the female deaf learners in the control group. Figure 2 reveals that the participants who had lower achievement motivation outperformed their counterparts with higher level of achievement motivation at both the treatment group 1 (CAI) and the control group, but performances were the same for all participants exposed to the Project-based Learning strategy.

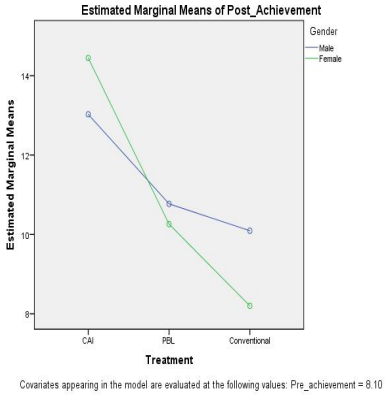

Figure 1 - Treatment against gender of participants

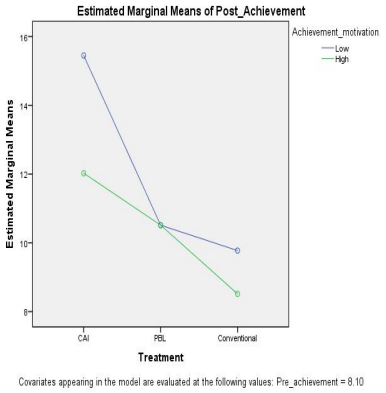

Figure 2 - Treatment against achievement motivation

9. Discussion

This study revealed that treatment significantly had effect on the achievement and performance of the participants on concepts of the digestive system. The participant exposed to CAI had higher posttest scores than those exposed to PBL and conventional teaching. This finding is in tandem with the findings of Yusuf and Afolabi (2010), Gürbüz & Birgin (2012), Nazimuddin (2015), Fırat, Gürbüz & Doğan (2016) and Gürbüz, Dede, and Doğan (2018). Based on the studies of Yusuf and Afolabi (2010) and Fırat, Gürbüz and Doğan (2016), current and geometric advances in new search for pedagogies to improve teaching, computer technologies with animation and simulation environment which learners can interact with and manipulate have great potential to enhance their learning abilities.

As observed in this study, Kareem (2015) as well as Gürbüz, Dede, and Doğan (2018) found that learners exposed to CAI, compared to learners taught, had increased ability to improve their academic performance and increased motivation to learning, as well as developed positive attitude towards abstract thinking and project-solving processes. This study also supports the findings of Yusuf and Afolabi (2010), Gürbüz and Birgin (2012) and Nazimuddin (2015), who confirmed that CAI is more effective in enhancing students' performance in other subjects than conventional classroom instruction. The participants exposed to the tutorial mode of CAI in this study experienced self-directed learning, which compensated for the loss in their sense of hearing with academic instructions and learning environment that appealed to the sense of sight.

The CAI approach used in this study proved more efficacious, as stated in Okoro and Etukudo (2001), Yenice (2006) and Gürbüz, Dede, and Doğan (2018), than other approaches used in the teaching of Mathematics and science instructions. Just like the studies of AltunYalçın et al. (2009), Bell (2010), Chang and Tseng (2011) and Ergül and Kargın (2014), this study found that PBL, though not as efficacious as CAI, improved the performance of deaf learners in Biology. There was a statistically significant difference in the posttest score of the participants in PBL and that of those in the control group. This study corroborates Ergül and Kargın (2014), whose study favoured the use of PBL for teaching Physics. The PBL differs significantly from conventional teaching because it provides learners with long-term activities and interaction. Krajcik and Blumen (2006) assert that PBL

provides learners with enough time to interact among themselves and make connection between activities and their environment.

The finding of this study showed no significant interaction effect of treatment and gender or interaction effect of treatment and achievement motivation on deaf learners' achievement in Biology but when the three dependent and moderator variables were combined, there was interaction among the variables. This finding supports Ekwueme and Umoinyang (2005), Obeka (2007), Yazdani and Godbole (2014) and Roy (2015), who attribute gender differences to various models of teaching and social interaction. Specifically, Ekwueme and Umoinyang (2005) reported that gender influenced achievement, while Danmole and Femi-Adeoye (2004) revealed that achievement of both males and females could be affected by teaching and learning styles. This study supports Liu and Zhu (2009), who found significant differences in achievement motivations of male and female senior high school students; the male students had higher achievement motivations than the female students.

10. Conclusion and recommendations

This study concludes that the Computer-Assisted Instruction (CAI) and Project-based Learning were more effective than the conventional classroom method of teaching biological concepts to deaf learners. However, CAI was found to be the best approach to use by teachers to teach scientific concepts to deaf learners. It creates an opportunity for the learners to interact with and use technology for their learning. The CAI and PBL are learner-centred instructional strategies that enhance active participation for learners in science classrooms.

Based on the findings, schools should encourage deaf learners to actively participate in science by adequate provision of technologies and practical equipment that can compensate for the loss of the sense of hearing. Teachers should also teach using computer-assisted instructional packages that learners can have access to any time, at school or at home. There is an urgent need for science teachers to be adequately trained on the use of CAI in teaching, particularly for teaching deaf learners in preparation for the world-driven by technology.

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