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Enhancing Problem Solving Skills in Trainee Teachers through Constructionist-Based Teaching Approach

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Abstract: This study investigates the Physics lecturers and the application of constructionist-based teaching approach in selected tertiary institutions in South-South/ South-East, Nigeria. The population consisted of 76 physics education lecturers in the selected tertiary institutions. The study posed 1 research question and 1 hypothesis. Survey research design was adopted for the study. Census sampling technique was adopted to select seventy-six (76) sample size. Self-structured questionnaire titled: Constructionist-Based Approach and Physics Education Lecturers Questionnaire (CAPELQ) was used for the data collection. The research supervisor and two lecturers in department of Curriculum Studies and Instructional Technology validated the instrument, while Pearson Product Moment Correlation (PPMC) was used for the test of reliability, which yielded reliability of 0.85. Out of the 76 distributed questionnaires, 65 respondents completed and returned the questionnaire, yielding 85.53% response rate, which includes 47 males (72%) and 18 females (28%). Mean and Standard Deviation were used to answer the research questions while Factorial Design ANOVA was used in testing the hypotheses at 0.05% level of significance. The findings showed that project-based and collaborative learning make the trainee teachers to learn better. Also, Physics education lecturers do not differ significantly in terms of qualification (F=0.42, p=0.959) and experience (F=0.214, p=0.808), but they differ significantly in terms of gender (F=10.700, p=0.002) over the utilisation of the constructionist-based teaching approach in teaching Physics. It is therefore recommended that the constructionist-based teaching approach should be adopted in preparing Physics teachers.

Keywords: Problem Solving Skills, Problem Based Learning, Constructionist Teaching Approach, Teaching, Learning.

Introduction

Problem-solving skills involve analysing the possible causes of a problem and developing an action plan that solves that problem. Problem-solving skills are constantly used both in personal and professional lives. Problem-solving skills comprise defining a problem; finding the cause of the problem; recognising, arranging, and choosing alternatives for a solution; and applying a solution. Problem-solving skill is a process (a continuing activity) in which we discover what we do not know via what we know. It involves overcoming obstacles by generating hypotheses, testing those hypotheses and arriving at satisfactory solutions.

Problem-solving skill involves three basic functions: (i) seeking information (ii) generating new knowledge and (iii) making decisions. Problem-solving skill is defined as a person's ability to engage in cognitive processes when understanding and solving problems for which the method of solving is not readily available (Shute, et al. 2016). Problem-solving skill is one of the important skills that should be provided to prospective teacher students because, in addition to developing thinking skills, it also trains students' ability to manage learning to develop thinking skills. Problem-solving is an important skill for students so it should be an important element of learning design at every point.

Constructionism is a constructivist learning theory which states that building knowledge occurs best through building things that are tangible and sharable (Ackerman et al., 2009: 56). "Constructionism (in the context of learning) is the idea that people learn effectively through making things. Constructionism relates to experiential learning and builds on some of the ideas of Jean Piaget." Constructionism emphasises the importance of the knowledge, beliefs and skills that an individual brings to the experience of learning (Garbett, 2011). Constructionism can be perceived as an educational theory, learning theory, an educational movement, or a philosophy of learning. Its common characteristics include active involvement of learners who are intrinsically driven, knowledge production by learners, social learning environment and social contact. The role of the teacher is redefined from that of a giver of knowledge to that of an organizer of necessary learning experiences or a coach who provides guidance that gradually decreases as learners become more proficient. Learning is reflective and builds on learners' existing knowledge. The goal of instruction in a constructionist's sense is not the acquisition of the basic knowledge but conceptual development and deep understanding.

The Tenets of Constructionist-Based Teaching Approach

Constructionist-based teaching approach advocates learner-centred, discovery learning where learners use what they already know, to acquire more knowledge. The following teaching models will be discussed in this work: (i) Problem-based learning, (ii) Project-based learning (iii) guided discovery learning, (iv) collaborative learning and (v) experiential learning.

(i) **Problem-Based Learning (PBL)**

Problem-based learning is a constructionist method which allows learners to learn about a subject by exposing them to multiple problems and asking them to construct their understanding of the subject through these problems. This kind of learning can be very effective in mathematics and science classes because learners try to solve the problems in numerous ways, stimulating their minds.

(ii) **Project-Based Learning**

Project-based learning is a learner-centred pedagogy that involves a dynamic classroom approach in which it is believed that learners acquire a deeper knowledge through active exploration of real-world challenges and problems (Yasseri et. al., 2018). Project-based instruction differs from traditional inquiry by its emphasis on learners' collaborative or individual artifact construction to represent what is being learned.

(iii) **Guided Discovery-Based Learning**

Discovery-based learning is typically characterized by having; (i) minimal teacher guidance, (ii) fewer teacher explanations, (iii) solving problems with multiple solutions, (iv) use of hand-on materials, (v) minimal repetition and (vi) memorization. The outcome of guided discovery-based learning is the development of inquiring minds and the potential for life-long learning. Discovery learning promotes learners' exploration and collaboration with teachers and peers to solve problems. Learners are also able to direct their own inquiry and be actively involved in the learning process which helps with learners' motivation.

(iv) **Collaborative Learning**

An important aspect of collaborative learning is the move from assimilation to construction, which is creating new understanding hinged on learners' discussions. Collaborative learning requires cognitive and environmental determinants. Social presence is required to enhance social interactions, which is a major tool for collaborative learning (Laal & Ghodsi, 2012). Therefore, collaborative learning shows a significant effect on learners' social interaction skills. The constructionists believe that collaborative learning encourages learners to team up best with one another while enhancing socialisation among themselves.

(v) **Experiential Learning**

Experiential learning is an engaged learning process whereby learners "learn by doing" and by reflecting on the experience. Experiential learning activities can include, but are not limited to, hands-on laboratory experiments, internships, practicums, field exercises, study abroad, undergraduate research and studio performances. Experiential learning contains all the following elements: (i) reflection, critical analysis and synthesis, (ii) opportunities for learners to take initiatives, make decisions, and be accountable for the results, (iii) opportunities for learners to engage intellectually, creatively, emotionally, socially, or physically and (iv) a designed learning experience that includes the possibility to learn from natural consequences, mistakes, and successes.

Theoretical Framework

The study was guided by Jerome Bruner's Discovery Theory of Learning, which was propounded by Jerome Bruner in 1966. Bruner posited that the learner must think and explain his way of reasoning to the teacher instead of memorising what was taught by the teacher. A major theme in the theoretical framework of Bruner is that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. Cognitive structure (i.e., schema, mental materials) provides meaning and organization to experiences and allows the individual to "go beyond the information given". Bruner (1966) states that a theory of instruction should address four major aspects: (i) predisposition towards learning, (ii) the ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner, (iii) the most effective sequences in which to present material, and (iv) the nature and pacing of rewards and punishments.

Good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information. In his more recent work, Bruner (1986; 1990; 1996) has expanded his theoretical framework to encompass the social and cultural aspects of learning as well as the practice of law which is one of the major objectives of science teaching/learning. The application of Bruner's theory of learning to science teaching/learning is that the science teacher should intentionally create or present to learners either in form of apparent contradiction or inconsistency among sources of information which are given in the process of instruction. Encouraging discovery learning in science class by science teachers will result into aiding problem solving. Learners should be taught concepts in such a way that they have applicability beyond the situation in which they were taught.

Statement of the Problem

It has been observed that many Sciences, Technology, Engineering and Mathematics (STEM) learners are unable to understand and assimilate STEM concepts or employ the said knowledge in new situations. STEM subjects are generally regarded as very difficult subjects in Nigeria. The genuineness of this outcry is depicted by the deteriorating poor performance of learners in examinations. According to Taangahar and Ameh (2019), there is a low students' academic performance in physics which is because of their belief that physics is a difficult subject. Although several attempts have been made at improving quality teaching, these efforts have not been proportionately reflected in learners' overall performance. The serious problem in Nigeria is that very little is being done to alter this situation (Adul, 2011). The Nigerian Educational System has experienced deep crises for many years. One of the factors that could be responsible for the downward trend in learners' performance is their negative attitude towards the subjects. Secondly, teacher's failure to employ appropriate methods of teaching scares the learners away from the subject. Thus, the efficacy of constructionist-based instructional strategy is attempted to fill the vacuum between the situation and existing research.

The search for an effective method of teaching Physics as one of the STEM subjects has necessitated the need to employ more interactive and knowledge construction approach for improved teaching and learning. The teaching approach that advocates knowledge construction approach is the constructionist-based approach. The contradictory evidence in achievement and interest has resulted to the need to verifying if constructionist-based teaching approach is used in Physics teachers training in the selected tertiary institutions in South-South and South-East, Nigeria.

With the poor performance in Physics, one is tempted to raise the following questions: is the problem with the teachers or the learners, what are the teaching methods employed by the teachers, do they consider individual differences in teaching the subjects, are the problems with the learners amongst others? This study therefore looked at the aspect of the teaching methods to see if appropriate teaching methods are being used in the preparation of Physics teachers, hence the quest for this investigation.

Aim and Objective of the Study

The study explores the efficacy of the constructionist-based approach in advancing Physics teachers' training in the selected tertiary institutions. Specifically, the study is designed to determine if Physics education lecturers adopt the tenets of constructionist-based approach in pedagogical training.

Research Question

The research question formulated to guide the study was: Do Physics education lecturers adopt the constructionist-based learning approach in pedagogical training?

Hypothesis

The null hypothesis that guided the study was:

Ho_1: There is no significant difference in Physics education lecturers adopting the tenets of constructionist-based teaching approach in pedagogical training based on gender, years of experience and qualification.

Methodology

The study was carried out in some selected tertiary institutions in the South-South/ South-East of Nigeria. The research adopted a survey research design. The population for this study consisted of all the Physics education lecturers in the seven (7) selected tertiary institutions in South-South/South-East, Nigeria. The number of Physics education lecturers from the seven tertiary institutions offering Physics Education as a course of study was seventy-six (76).

Table 1: Distribution of Population Table

S/N	NAMES OF SCHOOLS	MALE	FEMALE	TOTAL
1	University 1	-	3	3
2	University 2	11	1	12
3	University 3	2	1	3
4	College of Education 1	14	1	15
5	College of Education 2	12	3	15
6	College of Education 3	3	6	9
7	College of Education 4	14	5	19
	TOTAL	**56**	**20**	**76**

Source: Field Survey, 2021/2022.

The research adopted census sampling technique. All the Physics Education lecturers were selected and used in the study, giving a total of seventy-six (76) from the seven (7) selected tertiary institutions in South-South/South-East. The instrument used for data collection was a questionnaire titled 'Constructionism Approach and Physics Education Lecturers' Questionnaire (CAPELQ). The questionnaire was divided into section A and section B. Section A sought bio data of the lecturers such as name of school, gender, qualifications and others, while section B of the questionnaire contained ten (10) items on a four Likert scale of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) where the respondents were expected to tick based on the degree of agreement or disagreement to each of the items' statements. The responses were scored as follows: SA = 4, A = 3, D = 2 and SD = 1 to achieve a criterion mean score of 2.50, i.e., 10/4 = 2.50.

For the validity of the instrument, three lecturers in department of Curriculum Studies and Instructional Technology looked at it and made necessary corrections before it was given to the respondents. To determine the reliability of the instrument the split-half method was used. The Constructionism Approach and Physics Education Lecturers' Questionnaire (CAPELQ) was administered to the 10 education lecturers and their responses were collected and split into two halves and were correlated using Pearson Product Moment Correlation (PPMC) formula which yielded the value of 0.85. This indicated high coefficient and so was used for the study.

The researcher administered the Constructionism Approach and Physics Education Lecturers' Questionnaire (CAPELQ) to the selected lecturers. Out of the 76 distributed questionnaires, 65 respondents completed and returned the questionnaire, yielding 85.53% response rate. This included 47 males (72.31%) and 18 females (27.69%). The statistical tools used for this study were mean and standard deviation, to answer the research questions while Factorial Design Analysis of Variance was used in testing the hypotheses at 0.05% level of significance.

Results

Research Question 1: Do Physics education lecturers adopt the tenets of constructionist–based approach in pedagogical training?

Table 1: Summary of descriptive statistics on the adoption of the tenets of constructionist –based approach in pedagogical training by Physics education lecturers.

S/N	Utilisation of Constructionist-Based Learning Approach in Pedagogical Training by Physics Education Lecturers	SA	A	D	SD	N	$\bar{x}$	σ
1	The adoption of project-based learning approach in pedagogical training makes the Physics teacher trainees to be actively involved.	50	10	5	0	65	3.69	0.61
2	The adoption of problem-based learning approach in pedagogical training makes the learning environment to be democratic for Physics teacher trainees.	25	33	7	0	65	3.28	0.64
3	The adoption of guided discovery-based learning approach in pedagogical training makes learning activities to be interactive.	32	25	8	0	65	3.37	0.69
4	The Physics education lecturers facilitate a process of learning in which learners are encouraged to be responsible and autonomous.	28	35	2	0	65	3.40	0.55
5	Experiential learning when adopted as a learning approach in pedagogical training of Physics teachers makes learning activities to be learner centred.	42	23	0	0	65	3.65	0.48
6	Social interaction of Physics education lecturers encourages learners to reflect, evaluate their work, and identify intermediary skills needed in learning Physics.	21	34	9	1	65	3.15	0.71
7	The exposure of learners to collaborative learning promotes diverse viewpoints in learning Physics.	36	20	8	1	65	3.40	0.76
8	Discovery learning helps Physics teacher trainees to develop advanced skills such as critical thinking, analysis, evaluation, and creativity.	30	34	1	0	65	3.45	0.53
9	The project work assigned to Physics teacher trainees encourage them to identify the skills they need to develop in order to improve in Physics courses.	40	21	4	0	65	3.55	0.61
10	The use of problem-solving teaching approach in pedagogical training can help learners develop research skills that will enable them to teach and learn Physics.	35	21	9	0	65	3.40	0.72
	Grand mean						**3.43**	**0.63**

The mean ratings of the responses of Physics Education lecturers in Table 1 ranged from 3.14 to 3.69 which are all greater than mean value of 2.50 on the 4-point Likert rating scale. This showed that the ten identified items in the table are agreed on by the Physics education Lecturers. The standard deviation, which ranged from 0.48 to 0.76 showed that the responses of the respondents are not only close to the mean but close to one another. Specifically, the result showed that the respondents strongly indicated that the adoption of project-based learning approach in pedagogical training makes the Physics education trainees to be actively involved ($\bar{x}$ =3.69, σ =0.61). This was followed by experiential learning when adopted as a learning approach in pedagogical training of physics education trainees makes learning activities to be learner-centred ($\bar{x}$=3.65, σ =0.42) and the project work assigned to physics education trainees encourage learners to reflect on their progress and identify the skills they need to develop to improve ($\bar{x}$=3.55, σ =0.61). The least was social interaction of Physics education lecturers encourages learners to reflect, evaluate their work, and identify intermediary skills needed in learning physics ($\bar{x}$=3.15, σ =0.71).

Ho_1: There is no significant difference in Physics education lecturers adopting the tenets of constructionist–based teaching approach in pedagogical training based on gender, years of experience and qualification.

Table 2. Summary of factorial ANOVA on the difference in the Physics education lecturers' utilisation of the constructionist-based teaching approach based on gender, years of experience and qualification.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig. (p)
Corrected Model	0.612a	14	0.044	1.357	0.210
Intercept	253.245	1	253.245	7863.721	0.000
Gender	0.345	1	0.345	10.700	0.002
Qualification	0.003	2	0.001	0.042	0.959
Teaching experience	0.014	2	0.007	0.214	0.808
Error	1.610	50	0.032		
Total	767.970	65			
Corrected Total	2.222	64			

a. R Squared = .275 (Adjusted R Squared = .072)

The result from table 2 on the difference in the Physics education lecturers' utilisation of the constructionist-based teaching approach based on gender, qualification and experience showed that the physics education lecturers do not differ significantly in terms of qualification (F=0.42, p=0.959) and experience (F=0.214, p=0.808), but they differ significantly in terms of gender (F=10.700, p=0.002), over the utilisation of the constructionist-based learning approach in teaching Physics. The null hypothesis was rejected in terms of gender but was retained in terms of qualification and years of experience.

Summary of Findings

The result from table 1 shows the summary of descriptive statistics on the Physics education lecturers' adoption of tenets of constructionist-based instructional approach. Specifically, the result shows that the respondents strongly indicated that the adoption of project-based learning approach in pedagogical training makes the Physics education lecturers to be actively involved (x=3.69, σ =0.61). This was followed by experiential learning when adopted as a learning approach in pedagogical training of physics education trainees makes learning activities to be learner-centred (x=3.65, σ =0.42) and the project work assigned to physics education trainees encourage learners to reflect on their progress and identify the skills they need to develop in order to improve (x=3.55, σ =0.61). The least was social interaction of Physics education lecturers encourages learners to reflect, evaluate their work, and identify intermediary skills needed in learning physics (x=3.15, σ =0.71). The result further shows that the grand mean rating of the Physics education lecturers over the utilization of the tenets of constructionist-based learning approach was 3.43, with a standard deviation (σ) of 0.63.

The result from table 2 on the difference in the Physics education lecturers' utilisation of the constructionist-based learning approach based on gender, qualification and experience showed that the physics education lecturers do not differ significantly in terms of qualification (F=0.42, p=0.959) and experience (F=0.214, p=0.808), but they differ significantly in terms of gender (F=10.700, p=0.002), over the utilisation of the constructionist-based learning approach in teaching Physics. The null hypothesis was rejected in terms of gender but was retained in terms of qualification and years of experience.

Discussion of Finding

The discussion of findings for this study is based on the research question and hypothesis that guided the study. Result from research question 1 (Table 1) shows the summary of descriptive statistics on the Physics education lecturers' adoption of tenets of constructionist-based instructional approach. Specifically, the result shows that the respondents strongly indicated that the adoption of project-based learning approach in pedagogical training makes the Physics education lecturers to be actively involved ($\bar{x}$ =3.69, σ =0.61). This was followed by experiential learning when adopted as a learning approach in pedagogical training of physics education trainees makes learning activities to be learner-centred ($\bar{x}$ =3.65, σ =0.42) and the project work assigned to physics education trainees encourage learners to reflect on their progress and identify the skills they need to develop in order to improve ($\bar{x}$ =3.55, σ =0.61). The least was social interaction of Physics education lecturers encourages learners to reflect, evaluate their work, and identify intermediary skills needed in learning physics ($\bar{x}$ =3.15, σ =0.71). The result of HO1 (Table 2) on the difference in the Physics education lecturers' utilisation of the constructionist-based learning approach based on gender, qualification and experience showed that the physics education lecturers do not differ significantly in terms of qualification (F=0.42, p=0.959) and experience (F=0.214, p=0.808), but they differ significantly in terms of gender (F=10.700, p=0.002), over the utilisation of the constructionist-based learning approach in teaching Physics. The null hypothesis was rejected in terms of gender but was retained in terms of qualification and years of experience.

This result is in agreement with Adekoya and Olatoye (2011) and Ezeudu (2013) which indicated that project- based learning method improves learners' achievement in sciences more than the traditional teaching methods like lecture and demonstration. Zakaria, et al (2010) and Baran et al. (2018) also agree that innovative learning methods such as problem-based, project-based, gaming, collaborative and guided discovery learning methods improve learners' ability. This study has established that the adoption of the tenets of constructionist-based learning approach such as project-based, problem-based and collaborative learning methods enhance the performance of Physics teacher trainees in Rivers State and Nigeria.

Conclusion

The star deduction of the study is that project-based and collaborative learning make the physics education trainees to learn better when using constructionist-based approach to teach Physics education in the tertiary institutions. The interest of Physics education lecturers in adopting the tenets of constructionism was high. Conclusively, Physics education lecturers do not make any difference in terms of qualification and years of experience but make huge difference in gender, in the application of constructionist-based approach. Gender does not make any difference, but qualification and years of experience make much difference over the interest to utilising constructionist-based teaching approach. This study showed that the application of the constructionist-based learning approach by the Physics education lecturers, irrespective of their gender, years of experience and qualifications increases the trainees' knowledge in producing more independent and social Physics teachers who can impart knowledge to their learners and make significant impact in teaching and learning of Physics.

Recommendations

With respect to the findings of this study, the following recommendations are hereby made:

1. Physics education lecturers should adopt the constructionist-based approach in training their trainees.

2. The Physics education lecturers should learn to work in collaboration with their peers to effect social interaction in the use of constructionist-based learning approach.

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