

Impact of Constructivist Model-Based Training Programmes on Pre-Service Teachers' Knowledge, Creativity, Classroom Practice and Junior Secondary Schools Learning Outcomes in Mathematics

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Abstract

The dwindling performance of Junior Secondary School (JSS) students in Mathematics over the year needs urgent attention. This trend has been attributed to poor instructional strategies and teachers' inability in providing opportunities for creative thinking and ways of working mathematics. Scholars have advocated the use of creativity which begins with curiosity and involves pupils in exploration and experimentation which they draw upon their imagination and originality. This study therefore determined the use of constructivist method on pre-service teachers' knowledge and creativity, and students' imaginations on learning outcomes in mathematics. Pre-test, post-test, control group, quasi-experimental design with 3 x 3 x 2 factorial matrix was adopted for the study. Thirty six (36) pre-service teachers were selected using stratified sampling techniques. Eight hundred and thirty (830) students from six randomly selected secondary schools in southwestern Nigeria participated in the study. The instruments used were interactive approach knowledge and creativity (IAKC) validated using KR₂₀ (r=0.73) and problem-based learning knowledge and creativity (PBLKC) validated using KR₂₀ (r=0.74). Questionnaire on classroom teachers' practices and creativity were validated using inter-rater reliability index using Scott's IT (r=0.72). Data collected were analysed using Analysis of Covariance (ANCOVA) and Duncan pair-wise comparison test. Results showed that there were significant main effects of training programme on pre-service teachers' knowledge ($F_{(2,32)}=11.23; p < 0.05$) and creativity ($F_{(2,32)}=18.32; p < 0.05$). There was a significant main effect of pre-service teachers' knowledge and creativity on students' achievement ($F_{(2,811)}=110.66; p < 0.05$) and students' creativity ($F_{(2,811)}=3.39; p < 0.05$) towards mathematics. The CM pedagogy was more effective in improving classroom practices of pre-service teachers and it is the strategy that supports such outcomes which are clearly and vitally important to mathematics and particularly significant for a curriculum area in which both the spoken and written languages of mathematics are key to understanding.

Keywords: Constructivist, Pre-service, Creativity, Learning outcomes, Mathematics

Background to the study

Academic achievements and learning outcomes in Mathematics have become worrisome for Mathematics educators, researchers, parents and other stakeholders in the education industry. Statistics released by the Federal Ministry of Education (FME, 2006) on students' performance from (2000-2006) pointed to the fact that students perform very poorly in Mathematics.

Table 1: Data on Students' Performance in May/June SSCE Mathematics 2000 – 2006

YEAR	NO OF CANDIDATE	A1 – C6	%	D7- E8	%	F9	%
2003	756680	138098	18.25	212514	28.08	106068	53.66
2004	530074	173816	32.79	174819	31.09	191439	36.12
2005	1023102	383855	37.53	324907	31.76	314240	30.17
2006	908235	309409	34.06	308369	33.95	290457	31.98
2007	926212	341928	36.91	331348	35.11	229878	23.74
2008	8326898	287484	34.52	245071	28.22	300134	34.74
2009	1054853	402982	38.20	27600	25.36	363055	34.41
	1181515	482123	41.73	366801	31.55	292560	25.13

Statistics in Table 1 represent seven-year reports of the level of performance of secondary schools.

students in Nigeria in the public examination (WASC) between 2003 to 2009 which gives credence to what has been said about the poor performance of secondary school students in WASC examination in Mathematics on the dwindling performance of secondary school. Students in Mathematics in Nigeria needs urgent attention. This trend has been attributed to poor instructional strategies, basically teachers centred and these do not give opportunity to student to think. Scholars had advocated use of constructivist Mode (CM) which is student centred and also allows active participation of students in the teaching – learning situations. This study therefore, determine the use of Constructivist strategies on pre-service teachers knowledge, creativity, classroom practices and junior secondary schools students' learning outcomes in Mathematics.

Many Educators may not be familiar with the term constructivism but probably recognize that it has something to do with learning. The main tenet of constructivist learning is that people construct their own understanding of the world and in turn their own knowledge. Constructivist view of learning affects teaching, classroom practices and the students classroom behavior. The teacher's role in using constructivist strategy include modeling, scaffolding, selection and appoint of leader, grouping of students, determine the group goals, facilitator and assessor in teaching and learning situation.

Constructivist as an Instructional model seems therefore to be very inclusive and integrative, since it can involve the use of inquiry, Analog problem solving and the pre-social cooperative learning. Also included are: Computer simulation (Raltray Wood and Ferguson), concept mapping (Novak, 1991).

In this research work, the use of interactive Approach (Fleer, 1992) and problem-Based learning (PBL) with focus on Barrow Mode I(1984) was adopted. For interactive approach learners work together as peers applying their combined knowledge together to the solution of the problem. For interactive approach as used in this study include the following instructional steps.

Preparation (5-10mins) This involve the grouping or categorizing of the students into 5 or 7 depending on the class size and availability of materials.

Exploration

- Engage in focused play
- Look for information
- Listen to others
- Design model
- Question authority
- Share knowledge
- Analyze data

Propose Explanation

- Communicate information and idea
- Explain model
- Evaluate peers
- Answer questions
- Construct review
- **Talk in Action (spread over several sessions (10-15)**
- Apply knowledge
- Share information and ideas
- Develop product
- Ask new question
- Transfer knowledge and skills

Review initial and evaluation (10mins) This is the final stage.

The benefits of using the interactive Approach is summarized below as:

- Promote face to face interaction
- Provide opportunities for collaboration
- Students learn from each other
- Everyone participate and contribute
- Provide cohesion to learn and
- Provide basis for displaying of interpersonal skills in (communication decision making and resolution.

Problem Base Learning (PBL) is one of the many approaches to collaborative learning. PBL is based on constructivist theory of learning with understanding that learning is contextual, real world, complex problem solving learning, cognitive dissonance and collaborative decision. The learning procedure include the following

- Working in group
- Analyzing complex problem
- Working together to solution

- Students develop problem-solving skills
- Practice decision making
- It involves problem design
- Strategies selected for solution to problem
- Information assembled
- Assessment followed.

In using PBL, the following benefits are identified:

- Leadership is transferred into partnership between students and facilitator and the knowledge power empowering the student.
- PBL demand more responsibilities from students who have become active problems solvers in the teaching and learning process
- The method is used to transmit content and concepts from the instructors to the student. This assumes that students are responsible for the information and the knowledge stockable

The world in which one live requires the ability to innovate, discover, solve complex challenging an important problems, make decision and design and build on innovative products. Also, Nation all over the world pay keen attention to the nurture of creativity. How one promote creativity on the part of students” is onus on the creativity and classroom practice of teachers.

Lev. Vygostky (1962), developed the interactive approach to learning, Vygostky’s main relevance to constructivism derives from theories about language thought and their meditation by society (Bruffe, 1983). Vygostky’ social construction shows that knowledge is constructed through the interplay between child prior experience that learning is a process of knowledge construction that occurs through interaction in the social world, which situate the child (Von Glasser Red, 1986).

Lebow, (1993) developed Problem-Based learning in which students collaborates to study, the issues of a problem as they strive to create viable solutions. Unlike traditional instruction, which is often conducted in lecture format, teaching in problem based learning normally occurs within small discussion group of students facilities by a teacher or faculty tutor (Aspy and Blake & Hallinger, 1991). Using problem Based learning the assessment at the end of the process is in terms of peer and self evaluation.

Research evidence suggests that the adoption of learner centred strategy based on constructivist strategy can improve learners academic achievement in Mathematic with meaningful processed material did not fade easily from the memory. Von. Voohis (1991), Stevenson, (1988), Ampiah (2002), Asim, (1998), Blesati, 2003 Awolola (2009), Olosunde, (2009). Constructivist learning is ateaching strategy that can be used to help students of differentiability leves ,solve problems by working together .The key to Constructivist learning is that each member of the team has important role and responsible to all other members of the group. Constructivist learning not only helps in teaching aparticular topic in a lesson but forsters teamwork and promote social skills.

Another Prominent factor that have been identified to contribute to poor learning outcomes in Mathematics is classroom practice of teacher. This refers to specific teachers’ and pupils activities in the classroom. The crucial role of teachers in the teaching-learning situation and the need to improve teaching and learning cannot be over-emphasized. In developed countries, teacher effectiveness has long been a topic of popular and academic interest.

Gagne and Ryan (1974) in Chacko (1981) consider a teacher who contributes to the overall development of the child to be effective in the classroom practices. Davis (1986) consider cognitive gains of the students as an indicators of teachers effectiveness. In other areas classroom effectiveness is defined in terms of personal qualities of the teachers like personality experience and qualification.

Wengimsky (2000), in his study on how classroom practice significantly affects students achievement observes that teacher should use constructivist model procedure before implementing them with academic tasks. They should also set team goals and provide positive reinforcement for the teams and teacher should evaluate success of constructivists model earning activity.

Vartuli (1989), surveyed practicing teachers. In his study, the teachers were surveyed in classroom at the pre-school (Head start) through third grade levels. Again, the result indicates that the teachers with Education (NCE & B.ed) have higher mean scores in classroom practice than B.Sc) and Non certification in Education also found that primary level teaching kindergarten through third grade expressed attitude more aligned than degree with precisely teaching experience at the pre service/level when compared with teachers with an (NCE & B.Ed) degree and experience below the primary level only one study has examined pre-services teachers using similar methodology. The problem is does cooperative Learning strategies affect achievement as standard test in measuration on students awareness of the possible learning styles may be prevalent in any classroom? It is suggested that teachers be made aware of how to differentiate their instructions to appropriately address their learning styles. It is necessary for teachers to enhance their knowledge of data driven instruction and incorporate lessons to meet the needs of differentiated learning styles in order to improve students

achievements levels as measured by high stakes testing.(Olosunde,2009).Social learning theories help students increase their knowledge by observing ,imitating,or socially discussing objectives which increses higher order thinking skills which will increases test scores.

Siraj –Blatchford, and Sylva (2002) in researching effective pedagogy in the early years, the researchers found that school children do best when they are engaged in activities that make them think deeply, particularly environments that encourage sustained shared thinking between adults and children make more cognitive, linguistic and social-behavioural progress.

Therefore, the study is interested in how discovering to discover to what extent teachers see Mathematics as providing opportunities for creative thinking and ways of working in Mathematics. What sort of things had they seen student do in mathematics that they identified as “creative”? What did they know about any official guidance on teaching early “written mathematics” How did their understanding of early childhood development-particularly of the importance of self-initiated, play, talk, thinking and mark-making to supports students’ learning inform their practice?

In a study conducted by Craft (2002) on the role of creativity in the early years revealed that 65% of teachers thought that mathematics was either “quite’ or “lot of creative. 29% thought it was ‘very creative. The majority (over 79%) gave non-specific examples (resources or activities) of students engaged in ‘creative’ mathematics. In a nutshell teachers tend to see creativity in Mathematics as concerned with specific resources or activities, rather than processes.

In what ways were students similar and different in their beliefs as they began the classroom experience as a student teacher? Thus study addresses the question of whether after a learning programme in constructivist model, pre-service teachers would subsequently be able to implement constructivist model in their classes. In this study also, composite scale score were analyzed as well as sub-scale score of conceptually related items to provide a gained score and difference between students their classroom practice and creativity in Mathematics discipline.

Statement of the problem

Several attempts have been made by Mathematics Educators and researchers to improve achievement in Mathematics worldwide. Such attempts have been in the form of development and implementation of new curricular packages and better teaching strategies. It is evident that innovative strategies are learners centred are in favour of conceptual, sequential and logical aspects of Mathematics, none of them has probable not taken into consideration the effect of classroom practices of pre-service teachers in Nigeria as a variable that can improve the achievement of students in Mathematics. The present study determinend the effect of constructivist model-Based training programmes on pre-service teachers knowledge, creativity and classroom practices on learning outcomes in Mathematics. It also examined how constructivist strategy and traditional method of pre-service teachers at the beginning and end of their teaching practice program compare to each other with regard to belief about primary classroom curriculum and instruction practices.

Hypotheses

There is no significant effect of constructivist model-Based training programmes of pre-service teachers knowledge, creativity, classroom practices on students achievement in Junior School Mathematics.,

Methodology

The study adopted the pre-test, post-test control group quasi experimental design. The independent variables are at three levels (interactive approach, Problem Based Learning and Modified lecture method) and Moderator variables (teacher classroom practice and student gender). While dependent variables was achievement in Mathematics.

Participants/Sample of the Study

One approach to conceptualize and characterize diversity in the Nigerian context is geographical diversity within the country. Nigeria has been divided into six geo-political zones. The samples were therefore drawn from south western region. The zone which had early contact with western Education

The target population of the study comprised all the pre-service Mathematics teachers in the Colleges of Education were purposively selected and stratified along state and Federal Colleges of Education in South-Western part of Nigeria. Thirty six (36) pre-service teachers from public colleges of education in south-western Nigeria participated in the study. Homogeneous samples of pre-service Mathematics teachers were selected in each of the three colleges of Education were randomly selected for the study.

At the time of data collection all of the participated pre-service teachers were within one academic semester of graduation from an undergraduate program designed to prepare students for teaching middle school

Mathematics (sixth through eight grade) Two Federal and one state owned colleges of Education were sampled from south western Nigeria as important consideration for comparable standard in term of facilities and personnel. All the participants had completed courses in the major Mathematics content preparation in methodology courses designed to prepare them for teaching. General Education topics such as classroom management, instructional strategies and assessment had been explored by the participants. The pre-service teachers of Federal Colleges were exposed to the treatment while the state college were used as control. All these 36 pre-service teacher demonstrated these strategies on sampled schools and students, eight hundred and thirty Junior secondary school students from six randomly selected secondary schools in south western Nigeria participated in the study.

Instruments

Four Instruments were developed and validated by the researcher and used in this study.

1. **Training Package on Interactive Approach and Creativity (IAKC)**

Approach was adopted from Osinubi (2004) and which was modified by the researcher as stimulus instrument. It consisted of topics to be taught in the form of workshop to expose the pre service teachers to the interactive approach. The first draft of the instrument was subjected to a close examination by some expert in the field of education who read and commented on the instrument in term of adequacy of instructional steps, appropriateness of time allocation, appropriateness of activities as well as instructional materials. Based on their comments, necessary modifications were made and final drafts were produced. The instrument was validated using KR₂₀ with reliability of 0.73.

2. **Training Packages on Problem Based Learning and creativity (TPPBC)**

Teaching with Problem Based learning was adopted from Barrow (1992) with some slight modification for this study. It consisted of the topic to be taught in form of workshop to expose pre service teachers to the key structure of problem Based learning. The first draft was assessed by expert in the field of Evaluation who read and commented on the adequacy of the instrument. Based on their comments necessary modifications were made. The instrument was validated using KR₂₀ with reliability coefficient of 0.74.

3. **Teachers Guide on Modified Lecture Method (TGMLM)**

The Manual in form of lesson note was prepared by the researcher and supplied to all the pre-service teachers involved.

4. **Classroom Observation Schedule and creativity(COSC)** classroom observation schedule was adopted from Osinubi (2004). It was designed to measure the pre-service teachers classroom practice and the teacher –pupils’ interactive activities. It consisted items dealing with group activities and whole class activities involving teacher and the pupils. To establish the content and face validity of the instrument copies of the first draft were given to experts in the field of education especially in the area of evaluation for necessary comments as regards the suitability of the instruments based on their comments, certain modification were made.

The inter-rater reliability index of the instrument was estimated using Scott’s II for the Classroom observation schedule reliability of 0.76 was obtained.

5. **Questionnaire on Creativity for Interactive Approach and Problem-Based Learning**

The questionnaire contained 25- terms developed by the researcher on the creative ability of the pre-service teachers used during the training programme. The items were rated using four likert scale (SA, A, D,SD on the following.

- | | | |
|-------------------------------------|---|-----|
| • Role play | - | 20% |
| • Patterns | - | 20% |
| • Construction | - | 10% |
| • Shape | - | 10% |
| • Art (painting, printing, collage) | - | 10% |
| • Others | - | 20% |

The instruments was validated using a Scott;s II reliability coefficient of 0.72 attested to the adequate content validity of the instrument.

6. **Students’ Mathematics Achievement Test (SMAT)**

This test contains thirty multiple choice items that covered on the concepts in mensuration in Junior Secondary school curriculum. These items were developed using table of specification. The instrument reliability coefficient of 0.83 and average item difficult level obtained was 0.58.

TRAINING PHASE/RESEARCH ACTIVITIES

The training phase involved the implementation of **14 weeks** training programmes on constructivist strategies as follows:

Stage 1:

- Administration of the Instruments as pre-test (1 -2 weeks).
 - 30 items knowledge components of interactive approach to the service teachers
 - 30 items knowledge components of problem-Based learning to pre-service teachers.
 - Administration of questionnaires on creativity component of interactive approach and Problem Base Learning respectively.
- Orientation Programmes and workshops on Interactive Approach and Problem Base Learning (2 weeks)
- Demonstration of the strategies by the pre-service teachers (2 weeks)
- Administration of the instruments as post-test (30items of Interactive approach and Problem Base Learning and questionnaire on creativity.

Stage 2:

- Pre service teacher classroom practices
- Pre-test of students Mathematics achievement test (SMAT) to both interactive approach and problem Based Learning group (1 week)
- Demonstration of key structure of interactive approach and Problem Based Learning in Junior Secondary School. (6 weeks).
- Post-test of SMAT to both Interactive approach and problem based learning group (1 week)

RESULTS

Ho₁ There is no significant effect of constructivist model-based training programmes on pre-service teachers knowledge of the constructivist model instructions strategies.

Table 1 ANCOVA of Post Training Knowledge of Teachers by Treatment

Sources of covariate	Hierarchical				
	Sum of square	Df	Mean square	F	Sign
Covariate pre-knowledge	1.789	1	1.98	.772	.386
Main effects Treatments	52.286	2	26.143	11.233	.000
Model	54.083	3	18.028	7.740	.00
Residual	74.472	32			
Total	128.556	35			

A significant at P<.05

Table shows that treatment had a significant effect on pre-service Teachers knowledge of the constructivist strategies ((12,32) = 11.233, P< .05). The hypothesis was rejected. Here there is significant difference in the mean post training knowledge scores of pre-service teaches exposed to the interactive approach problem-based and convectional modified teaching programme.

The Multiple Classification Analysis (MCA) shows that exposed to the training programmes on PBL obtained highest adjusted mean post training knowledge score (x= 15.25) followed by Interactive Approach (x = 12.42) and modified lecture method (MLT = 12.42) obtained the lowest mean score.

HO₂: There is no signifidant effect of treatment in creative ability of teachers

Table 2: ANCOVA of Post training creativity score o Pre-service Teachers by Treatment

Sources of covariate	Hierarchical				
	Sum of square	Df	Mean square	F	Sign
Covariate pre-Attitude	81.306	1	81.306	1.318	.259
Main effects Treatments	899.523	2	449.761	7.290	.002
Model	980.829	3	326.943	5.300	.004
Residual	1974.171	32	61.693		
Total	2955.00	35	84.429		

Significant at P<.05.

From the table 2, there is a significant effect of treatment on post training creativity score of the pre-service teacher (F2,32=) 7.290 p<.05) therefore, hypotheses is rejected this means that the difference between the post-training score of pre-service teachers exposed to the interactive, problem based and convectional training programme is significant. The MCA shows that pre-service teaches exposed to the PBL (x=63.60) followed by Interactive Approach (x= 63.14) while Modified Lecture Method MLM (x=52.19) with lowest mean score.

HO₃: There is significant effect of treatment on classroom practices of pre-service Teacher.

Table 3: ANCOVA Post –Training Classroom Practice of Pre-Service teachers by treatment.

Sources of covariate	Sum of square	Df	Mean square	F	Sign
Convenient	16.856	1	16.853	.598	.445
Main Effect Test	1041.86	2	520.931	18.490	.000
Treatment	1058.714	3	352.905	12.519	.000
Resident	902.036	32	28.189		
Total	1960.750	35	56.021		

From the table 3, there is no significant effect of treatment on pre-service teachers' classroom practices ($F(2,32) = 18.480$; $P < .05$). This implies that hypothesis is rejected. The MCA showed that pre-service teachers exposed to the PBL ($x=52.75$) programme had the highest mean scores than interactive approach and MLM ($x=40.42$).

HO₄ There is no significant effect of treatment on students Achievement by treatment, Teachers Creativity and Gender

Table 4: ANCOVA Post Achievement, creativity and Gender of Pre-service teachers.

		Hierarchical Method				
	Sources of variation	Sum of square	df	Mean square	F	Sign
	Covariates PREA TT	914.425	1	914.425	9.998	.002
	Main effects(Combines)	11060.781	5	2212.156	24.186	.000
	Treatment	8255.279	2	4127.640	45.128	.000
	Tr creativity	621.561	2	310.781	3.398	.034
	TR GENDER	2183.940	1	2183.940	23.877	.000
2-way	Combined	7204.438	8	900.555	9.845	.000
	Treatment & Creativity	3427.753	4	856.938	9.369	.000
	TREATMENT & GENDER	926.196	2	463.09	5.063	.007
	Teacher Creativity & Gender	2626.714	2	1313.357	14.359	.000
3 way Interaction	Treatment & TR Creativity & Gender	1932.305	4	483.076	5.282	.000
	Model	21111.950	18	1172.886	12.823	.000
	Residual	74178.316	811	91.465		
	Total	95290	829	114.946		

- Significant of $P < .05$.

The table 4 showed that there was a significant effect of treatment on students' achievement in Mathematics ($F_{(2, 811)} = 14.248$, $P < .05$). Hence hypothesis is rejected. This means that the difference in the achievement mean scores of students exposed to interactive, problem based and convectional method was significant.

MCA showed that the students taught with PBL obtained mean achievement score of ($x=13.68$) followed by the interactive approach ($x=12.29$) and then modified lecture method ($x=11.44$). Scheffe post hoc analysis further revealed that the interactive approach ($x=12.28$) differs significantly from the modified lecture method ($x=11.44$). The PBL group ($x=13.68$) also differ significantly from the control group ($x=11.44$). However, the two experimental group does not significantly differ from one another.

Discussion and Recommendation

The major issue addressed in this study was to find out effect of constructivist model-based training programmes on pre-service teachers creativity, classroom practice on achievement Mathematics. The study discover to what extent teachers see Mathematics as providing opportunities for creative thinking and ways of working in Mathematics. What sort of things, had they seen students do in Mathematics that they identified as creative? What had they know about any official guidance on teaching early written Mathematics? How did their understanding of early childhood development – particular of the importance of self initiated play, talk, thinking and mark-marking to support children's learning inform their practice

- Teacher needs support to see that creativity does not depend on specific resources or activities and to recognize the importance of creativity throughout the curriculum.
- Teacher need help to recognize Mathematics within child-initiated play, talk and representation to understand that children can be highly creative in their Mathematics work-making and recognize the value of all forms of usual representations in supporting high levels of cognitive challenge.

The result of this study showed that there was a significant difference in the post classroom practice of pre-service teachers exposed to the constructivist model instructional strategies and conventional method. The result equally showed that the pre-service teachers in interactive approach group obtained the highest adjusted post training classroom practice score, than problem-based learning and modified lecture respectively in that order. This agreed with Olosunde(2009) and Osinubi(2004) which could be explained by the fact that this method of instruction emphasised self construction of knowledge and in making connections which are enhanced through active engagement of the learners. Active engagement is said to aid understanding and improve academic performance, attitude and classroom practice (Busari, 2003; Akinsola, 1994). Therefore, Constructivist learning enhanced achievement more than modified lecture method of instruction especially in the effective teaching of abstract concept in Mathematics.

Okebukola and Jegede (1988) in a study to find out if there was a significant treatment effects as a result of exposure to CM strategy when compared with the lecture method using 40 items achievement test. The result showed that post test mean score of CM showed significant differences than the control group.

The result of Weingimsky (2000) also established that classroom practice of teachers significantly affects student achievement and concluded that one of the most innovative strategies widely prescribed to manage and build upon the strength of the increasing diversity found in classroom is the constructivist strategies. (Slavin, 1995). Also researchers have established that constructivist strategy enhances classroom practices of teacher (Slavin, 1987, Lagoke, 1993, Osinubi, 2004).

Since the use of constructivist strategies has been found to produce effective improvement of teachers classroom practice as well as students' achievement more than the traditional lecture method, it becomes pertinent not only to pay attention to the training of pre-service teachers in the essential features of constructivist model.

Therefore, curriculum of teacher training institution should be organized to introduce teacher trainees to the constructivist methods of teaching Mathematics and how to apply them in secondary schools classroom in Nigeria. Also, lectures in the colleges/faculties of Education should be given on the job training through organized workshop, seminars, symposia and conference in order to expose them to all that is involved in the constructivist strategies.

Based on these findings recommendations such as inclusion of constructivist model in text and in teaching was made. It is hoped that the adoption of the recommendations would go a long way to help students perform better in science and mathematics.

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