

## LEARNING WHILE DOING MODEL AND SENIOR SECONDARY STUDENTS' LEARNING ACHIEVEMENT IN SOLID GEOMETRY

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### ABSTRACT

This study explored the effectiveness of Learning While Doing (LWD) instructional model for enhancing the learning achievement of senior secondary students in solid geometry in Emohua Local Government Area of Rivers State. The study adopted quasi-experimental design. A total of 60 Senior Secondary School I (SSS1) students participated in the study. The instrument used for data collection was Solid Geometry Achievement Test (SGAT). The Kuder-Richardson, KR-21 method was used to determine the reliability of SGAT to yield an index of 0.84. This exploration was guided by two research questions and two null hypotheses. The mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at .05 alpha level. The findings established that the students who were taught using LWD model gained more than those who were taught by Problem-based Learning (PbL) model over SGAT scores. The male students in the experimental group outperformed their male counterparts in the control group and the female students in the experimental group also outperformed their female counterparts in the control group. The result further showed that there was significant main effect of LWD on the learning achievement of students in solid geometry. However, there was no significant effect of sex on the learning achievement of the students in solid geometry. It was recommended among others that mathematics teachers should try to adopt the LWD instructional model in teaching solid geometry because of its efficacy in advancing students' learning achievement in solid geometry.

**Keywords:** Learning While Doing model, Solid geometry, Learning achievement.

### INTRODUCTION

The scientific and technological development of any nation depends on the effort made by such nation to advance her students in the learning of mathematics and other mathematical sciences. Mathematics is made compulsory at the primary and secondary levels of education in Nigeria because of its indispensability in the development of the nation. However the performance of students in external examinations in mathematics has not been encouraging. Factors such as poor teaching method, mathematics anxiety and dyscalculia among others have been implicated for this ugly trend. The adoption of inappropriate instructional model by the mathematics teachers could be considered as an overarching factor leading to poor performance of students in mathematics. Ogunkunle (2009) established that school teachers in Port Harcourt were ineffective in teaching mathematics as they apply conventional

instructional strategies in almost every topic taught. There is therefore the need for teachers to teach students with innovative and effective instructional models capable of making them independent thinkers and advance their higher order mathematics skills. One of such instructional models with the capacity of promoting students' mathematical creativity, favourable mathematical attitude and critical thinking skills is Learning While Doing (LWD) model.

### **Learning while doing model and students' learning achievement in science**

The Learning While Doing is an instructional model that is based on the constructionist theory of learning (Papert & Harel 1991). The LWD model entails collaboration, because the students work with mentors who are professionals, interaction is encouraged and learners are made to engage in real life problem-solving task performance while developing chosen projects (Tempel, 2007; Lough 2014a; Han & Bhattacharya, 2001). The LWD model is a form of Project-Based Learning (PBL) model, whereas the PBL is designed for the engagement of learners in the exploration of real-world task to create relevant and meaningful experiences. The PBL has been proven to be an effective learning model that creates an environment that aid students to have in-depth understanding of the content rather than just learning the content based on the conclusions of others (Özdemir, 2006; Cervantes, 2013).

Özdemir (2006) explored the efficacy of PBL in advancing the learning achievement and attitudes toward geometry among students. The finding of the study established that PBL enhanced the students' learning achievement and attitudes toward geometry. The experiment helped in increasing students' engagement in the learning activities. In a similar study by Baş (2011), the efficacy of PBL model in the improvement of students' academic achievement and attitudes toward English language was explored and findings established that PBL was more effective in the improvement of students' achievement levels than non-PBL instructions. Cervantes (2013) investigated the impact of PBL model on reading and mathematics among students in eighth grade. The findings established that PBL has positive impact on the learning achievement of students in mathematics and reading. Also, Bilgin, Karakuyu, and Ay (2014) explored the effects of PBL model on the self-efficacy belief and learning achievement of undergraduates in science teaching and views of students about PBL. The findings established that PBL model enhanced students learning achievement and self-efficacy. Most of the students who adopted the PBL model had more positive views of PBL.

Konrad (2014) investigated the effect of PBL on the learning achievement and motivation of students in algebra classroom. The findings among others showed that students learning advanced overtime. However, the improved outcome of the learners' result was not significant to suggest that PBL was the most efficacious learning model in high school. On comparison of the pre-assessment and the post-assessment scores, 60% of the male students and 75% of the female students advanced in their post-test score by 20% and above. The female students had a higher but insignificant rating on motivation over the male students. Grady and Ibrahim (2014) also explored the effectiveness of PBL in the learning outcomes and perception of students. The findings indicated that the male and the female students did not differ significantly over learning outcomes under PBL conditions. The students in the PBL environment were more motivated and preferred it to the conventional method. The study concluded that PBL is capable of enhancing the learning outcomes of students regardless of their gender.

## Problem specification

There are a lot of risks associated with producing students who lack the higher order mathematics skills of problem formulation, problem analysis and problem-solving. The students will be future leaders of the societal sectors and when these development process prospective leaders are deficient in these critical thinking skills, then the societal sectors is in danger. To raise students who are independent thinkers, capable of engaging in real life problem-solving, with enhanced understanding of mathematics, then teachers' adoption of innovative instructional model such as LWD becomes imperative. The present study is therefore designed to investigate the effectiveness of Learning While Doing model in the improvement of the learning achievement of students in solid geometry.

## Aim and objectives of the study

The aim of the present study is to investigate the effect of LWD model on the learning achievement of senior secondary students in solid geometry. In more specific terms the objectives of the study were to:

1. Determine the mean difference between the solid geometry learning achievement of senior secondary students taught using LWD model and those taught using PbL model.
2. Explore the mean difference in the learning achievement in solid geometry between the male and the female students taught using LWD model and those taught using PbL model

## Research questions

The following research questions guided the study

1. What is the mean difference between the solid geometry learning achievement of senior secondary students taught using LWD model and those taught using PbL model?
2. How might we describe the mean difference in the learning achievement in solid geometry between the male and the female students taught using LWD model and those taught using PbL model?

## Hypotheses

The following research hypotheses were tested at 0.05 alpha level.

**H<sub>01</sub>:** There is no significant mean difference between the solid geometry learning achievement of senior secondary students taught using LWD model and those taught using PbL model

**H<sub>02</sub>:** There is no significant mean difference in the learning achievement scores in solid geometry between the male and the female students taught using LWD model and those taught using PbL model

## METHODOLOGY

### Design

The study adopted the quasi-experimental design. The independent variable of the study was the adopted instructional models. The learning achievement of the students in solid geometry is the dependent variable. The design can be represented symbolically as shown on Table 1.

**Table 1: Research design**

Group	Pre-test	Treatment	Post-test
E	O <sub>1</sub>	X <sub>LWD</sub>	O <sub>2</sub>
C	O <sub>1</sub>	X <sub>PbL</sub>	O <sub>2</sub>

Where: SGAT= Solid Geometry Achievement Test

O<sub>1</sub> = Pre-SGAT,

O<sub>2</sub> = Post-SGAT,

E = Experimental group,

X<sub>LWD</sub> = Learning While Doing (LWD)

C = Control group

X<sub>PbL</sub> = Problem-based learning (PbL)

### Population, sample and sampling technique

The population of the investigation was all the 2190 public SSS1 students in Emohua LGA of Rivers State (Rivers State Senior Secondary Schools Board, 2015). A sample of 60 SSS1 students took part in the study. Two senior secondary schools were purposively selected and included for participation in the study based on some specified criteria, viz: school ownership, type of school (single sex or coeducation), availability of qualified mathematics teachers, concepts learned and registration of students for SSCE. One arm of SSS1 in one of the two selected schools was randomly assigned to the experimental group while the other was assigned to control group.

### Instrumentation

A researcher designed and validated 50-item multiple-choice instrument, Solid Geometry Achievement Test (SGAT) was used to quantify the solid geometry achievement of the students. It measured five content areas in SSS1 solid geometry, viz: total surface area and volume of solid shapes, frustum of cone and pyramid and composite solids. Kuder-Richardson, KR-21 technique was used to determine the reliability of the instrument to obtain a coefficient of 0.84.

### Data collection

The planning of the instructions and the development of the lesson plans were done by the researchers. The two mathematics teachers who participated in the study were trained on the theoretical and practical aspects of the exploration for two days. Prior to the commencement of the instructions and after the learning episode, the Pre-SGAT and the Post-SGAT were administered and retrieved.

**Intervention group:** The students in this group worked in groups of about five persons each. The LWD facilitation rules guided the instruction. The facilitator introduced the participants to the methodology that was adopted throughout the period of the experiment in large group. They were also introduced to real life complex problem-solving and systems thinking approaches. The participants were introduced to previous prototype projects for impression and materials in the store. They were also introduced to the LWD team tasks of stages 0-3, which includes (0) real life problem identification, (1) brainstorming for solution ideas, (2) solution concept development and (3) project development. The participants also practiced the project development routine in small groups. They were advised not to jettison crazy ideas when brainstorming for solution ideas. The students were guided to begin the development of their chosen projects in groups. The components of the projects to be presented were disclosed to the participants. The students in each group were allowed to collaborate; make organized noise while working on their projects and write journals of their

project development in a notebook. The teacher only walked around, asking probing questions when necessary in order to trigger students' critical thinking skills. The student groups were allowed to work collaboratively even outside school hours during this phase of their project development. By the end of the project development episode, the students shared their finished prototype projects in large group and all the groups contributed in critiquing each of the presented projects. The participants were encouraged to learn from their mistakes and to go back to refine their projects.

**Control group:** The five fundamental phases of problem-solving were used as the strategic components of the PbL model. Participants who adopted this model worked independently. The teacher presented the lesson by solving different solid geometry problems on the chalkboard while the students jot down important points. By the end of the teacher's instructions and explanations of all the problems solved, the students were asked to solve related problems following the strategic components, problem study, solution process planning, execution of solution plan, solution outcome evaluation, and problem mastery development.

### Data analysis

Descriptive and inferential statistics were applied in the data analysis. Mean and Standard Deviation (SD) were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at .05 alpha level.

## RESULTS

**Table 2: Mean, SD and learning gain of groups of students taught using LWD and PbL.**

Model	N	Pretest		Posttest		Gain		95% CI	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	LB	UB
LWD	30	25.53	6.45	55.67	6.22	30.13	9.87	26.45	33.82
PbL	30	26.73	5.72	48.60	8.16	21.87	10.54	17.93	25.80

Source: field work 2016,

Key: LB=Lower Bound (for gain scores), UB=Upper Bound (for gain scores), CI=95% Confidence Interval, N= Number of participants in each group,  $\bar{X}$  =Mean, SD= Standard Deviation

Table 2 shows that Post-SGAT mean score of the students who were taught using the LWD model was  $55.67 \pm 6.22$  and that of those who were taught using the PbL model was  $48.60 \pm 8.16$ . The mean learning gain of students who were taught using the LWD model was  $30.13 \pm 9.87$ , and the 95% confidence interval moved from 26.45 to 33.82. The mean SGAT gain score of the students taught using PbL was  $21.87 \pm 10.54$  and the 95% confidence interval moved from 17.93 to 25.80.

**Table 3: Mean, SD and gain scores of the male and female students taught using LWD and those taught using PbL.**

Model	Sex	N	Pretest		Posttest		Gain		95% CI	
			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	LB	UB
LWD	Male	18	24.78	5.75	56.00	4.99	31.22	7.39	27.55	34.90
	Female	12	26.67	7.50	55.17	7.93	28.50	12.94	20.28	36.72
PbL	Male	12	27.67	5.10	46.50	8.99	18.83	12.69	10.77	26.90
	Female	18	26.11	6.15	50.00	7.48	23.89	8.64	19.59	28.18

Source: field work 2016,

Table 3 shows that the mean SGAT score of the male students who were taught by LWD model was  $31.22 \pm 7.39$ , the upper and lower bounds of the 95% Confidence Interval (CI) were 27.55 and 34.90 respectively, whereas their female counterparts had mean gain score of  $28.50 \pm 12.94$ , with upper and lower bounds of the 95% CI as 20.28 and 36.72 respectively. The mean gain score of the male students who were taught using PbL was  $18.83 \pm 12.69$  with upper and lower bounds of the 95% CI as 10.77 and 26.90 respectively whereas their female counterparts had mean gain score of  $23.89 \pm 8.64$  with the upper and lower bounds of the 95% CI as 19.59 and 28.18 respectively.

**Table 4A: Summary of ANCOVA on SGAT scores based on treatment and sex**

Source	SS	df	MS	F	Sig.	$\eta^2$
Pre-SGAT	83.923	1	83.923	1.598	.211	.028
Treatment	719.961	1	719.961	13.712	.000	.197
Sex	26.874	1	26.874	.512	.477	.009
Error	2940.343	56	52.506			
Total	166872.000	60				
Corrected Total	3798.933	59				

a. R Squared = .226 (Adjusted R Squared = .185)

Part A of Table 4 shows that there was significant mean difference between the solid geometry learning achievement of senior secondary students taught using LWD model and those taught using PbL model ( $F_{1, 56}=13.712$ ,  $p=.000$ ,  $\eta^2=.197$ ). The  $H_{01}$  was rejected at .05 alpha level. The Table 4 further shows that there was no significant mean difference in the solid geometry learning achievement between the male and the female students taught using LWD model and those taught using PbL model ( $F_{1, 56}=.512$ ,  $p=.477$ ,  $\eta^2=.009$ ). The  $H_{02}$  was upheld at .05 alpha level.

**Table 4B: Simple-main effect analysis on SGAT scores**

	Independent variable	SS	df	MS	F	p-value	$\eta^2$
	Sex	LWD	1.448	1	1.448	.037	.850
PbL		75.850	1	75.850	1.124	.298	.040

Part B of Table 4 shows that the male and the female students taught using LWD do not differ significantly in their mean SGAT scores ( $F=.03$ ,  $p=.850$ ,  $\eta^2=.001$ ). Similarly, the result also shows that students who were taught by PbL do not also differ significantly in their mean SGAT scores based on sex ( $F=1.124$ ,  $p=.298$ ,  $\eta^2=.040$ ).

## DISCUSSION

### Learning While Doing (LWD) instructional model and students' achievement in solid geometry

The result from Table 2 shows that students who adopted the LWD instructional model outperformed their counterparts who were taught using PbL model over Post-SGAT scores with a mean difference of 7.07. Similarly, the students who were taught using LWD model gained more than those who were taught using PbL model with a mean gain of 8.26. This established the superiority of the LWD model over the PbL model in the improvement of the learning achievement of the senior secondary students in solid geometry. The progress in the learning achievement of the students in the experimental group may be linked with the real life problem-solving identification, brainstorming for solution, the solution concept development and the project development components of the model. The collaborative nature of the LWD model may have aided students who were taught using the model to advance in learning achievement over their counterparts. The statistical test on Part A of Table 4 shows that there was significant mean difference between the solid geometry learning achievement of senior secondary students taught using LWD model and those taught using PbL model ( $F_{1, 56}=13.712$ ,  $p=.000$ ,  $\eta^2=.197$ ). The  $H_{01}$  was rejected at .05 alpha level. This finding is in agreement with an earlier finding of Özdemir (2006) which explored the efficacy of PBL in advancing the learning achievement and attitudes toward geometry among students. The finding of the study established that PBL enhanced the students' learning achievement and attitudes toward geometry. The experiment helped in increasing students' engagement in the learning activities.

### Learning While Doing (LWD) model and gender associated achievement in solid geometry

The result from Table 3 shows that male students who were taught by LWD model outperformed their male counterparts who were taught using the PbL model with mean gain difference of 12.39. The female students who adopted the LWD model also outperformed their female counterparts who adopted the PbL model with mean gain difference of 4.61. The result from Part A of Table 4 showed that there was no significant mean difference in the learning achievement in solid geometry between the male and the female students taught using LWD model and those taught using PbL model ( $F_{1, 56}=.512$ ,  $p=.477$ ,  $\eta^2=.009$ ). The  $H_{02}$  was upheld at .05 alpha level. A closer peer at the result on Part B of Table 4 shows that the male and the female students taught using LWD model do not differ significantly in their mean SGAT scores ( $F=.037$ ,  $p=.850$ ,  $\eta^2=.001$ ). Similarly, the result established that students who were taught using PbL do not differ significantly in their mean SGAT scores based on sex ( $F=1.124$ ,  $p=.298$ ,  $\eta^2=.040$ ). This further justified the retention of the second hypothesis. This findings is in agreement with an earlier finding by Grady and Ibrahim (2014) who explored the effectiveness of Project-Based Learning (PBL) model in the learning outcomes and perception of students. The findings indicated that the male and the female students did not differ significantly over learning outcomes under PBL conditions. The students in the PBL environment were more motivated and preferred it to the conventional method. The study concluded that PBL is capable of enhancing the learning outcomes of students regardless of their gender

## CONCLUSION

The study has established that LWD model was superior to PbL in enhancing the learning achievement of students in solid geometry. Students in the LWD session gained in learning over time irrespective of their gender. However, both instructional models aided the improvement of learning of solid geometry concepts taught by the teachers. The collaboration and real life complex problem-solving through project development which formed the characteristics of the LWD model could be associated with the enhanced learning outcome. This proven efficacy of LWD in advancing the learning achievement of students is a pointer to the effectiveness of instructions based on constructionist theory of learning.

## RECOMMENDATIONS

The following recommendations have been made based on the findings of the study:

1. Mathematics teachers should try to adopt the LWD instructional model in teaching solid geometry because of its efficacy in advancing students' learning achievement in solid geometry. The students engaged in project develop phase of LWD are privileged to receive assistance from both their teacher and their classmates while solving real life problems.
2. To eliminate the existing gender inequity in mathematics learning achievement, both male and female students should be equally engaged in the LWD model classroom session. They should be allowed to interact, share ideas and have mathematical discussions while solving problems.

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