Path Analysis of the Effects of Science Literacy and Science Process Skills on Pre-Service Science Teachers' Efficacy Beliefs

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Abstract
The behavior of teachers in the achievement of educational goals has invisible complement known as teacher beliefs. In science education, the teachers' beliefs are not left out in leading the students to have a strong belief of succeeding in scientific processes which includes; observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting and communicating. These skills involves in a system known as the science literacy which has become a well recognized global educational slogan and contemporary educational goal. In view of this, the study focuses on path analysis of the effects of science literacy and science process skills on pre-service science teachers' efficacy beliefs. The study sample involved an intact class of pre-service science teachers in a college of education, south-western, Nigeria. The study answered two research questions in which teachers' efficacy beliefs was predicted by science literacy and science process skills. There was an alternate role of being extraneous and predictors by science literacy and science process skills in the research questions. The data analyzed revealed significant relationship among the three variables which is greater between science process skills and teachers' efficacy beliefs. Path analysis skewed towards the direction in which science literacy was the predictor of both science process skills and science teachers' efficacy beliefs. The study was concluded on the need for pre-service teachers' access to sources of positive experiences in teacher education. Intervention programs in teacher training were also raised for further studies to alleviate the teacher efficacy beliefs.

Keywords: Science literacy, Science process skills, Teachers' efficacy beliefs, Teacher training, Intervention programs

Introduction

The entire edifice of education is constructed on the foundation that teaching can contribute to accelerated and accomplished learning. Hence, the overall process of education certainly involves several players which includes; educational administrators, policy makers, curriculum planners, teacher trainers and teachers among others. However, the player who has a direct contact or bearing on shaping and reshaping the desired learning outcomes is the classroom teachers. These classroom teachers has been described by Kumaravadivelu (2003) to be an artist, architect, scientist, psychologist, manager, mentor, controller, counsellor, sage on stage, guide on the side and lots more . Consequently, the importance of the science teachers in the implementation of the science curriculum at all levels of education is acknowledged worldwide Gbolagade (2009). There is need therefore to constantly review and develop the skills and where withal required for making science relevant in the society.

Pre-service teacher's process skills according to Akpan (2010) are an aspect to be given considerable attention during the training period. This however, required drastic changes in attitude or teaching style but merely involves making the science process more explicit in lessons. It is of necessity as they are being trained to teach others later.

Scientific process skills as shown in Turiman, Omar, MohdDaud and Osman (2011) can be divided into two namely; the basic science process skills and integrated Science process skills. Basic science process skills includes; observation, classification, measurement, using numbers, making inferences, prediction, communication and using the relation of space and time. Integrated science process skills consist of interpretation of data, operational definition, controlling variables, making hypotheses and experimentation. Science process skills according to miller (2002) should be utilized by teachers in the delivery of teaching the facts of science effectively. This is because science is not just of knowledge but it is a way to systematically understand the environment and the world at large.

Science literacy plays an important role in human daily lives. Promotion of science literacy has been recognized as a major goal of science education in the world Zembylas (2002). Meanwhile, Hazen (2002) makes distinction between being able to do science and being able to use science. He stated that science literacy is a mix concept; history and philosophy that help one understand the scientific issues of our time. Hence, scientific literacy has been recognized as an important characteristic that every citizen in a modern society should possess. In this respect, science education which includes 21st century skills is critical for developing student's scientific literacy, which in turn will give rise to scientifically literate citizens in future.

Conclusively, a number of studies have also been conducted on the influence of teachers' gender on teaching. Capri and Cellkaleli (2008) discovered that gender has a significant influence on the professional teaching practice of pre-service teachers. Also, Bulut (2009) identified no difference in teaching efficacy irrespective of type of course and gender. Cerit (2011) discovered that there is a significant difference in teaching efficacy of male and female pre-service science teachers. In another study, Erdemand Demire (2007) shared that pre-service science teachers teaching efficacy

may vary in terms of their background information such as, gender, topic taught, subject combination and so on.

Therefore, this study investigated path analysis of the effects of science literacy and science process skills on pre-service science teachers teaching efficacy belief.

Research Questions

1. What are the levels of pre-service science teachers' science literacy, science process skills and science teaching efficacy belief?
*are there differences based on gender and subject combinations
2. What is the casual path relationships among pre-service science teachers science literacy, science process skills and science teaching efficacy believe

Research Methodology

This study used qualitative data collection of self-report questionnaire containing two sections. Section A comprises of Bio-Data of the respondents as well as their subject combinations. While section B having three (3) parts seeking information on
1) Science literacy of the pre-service science teachers
2.) Science process skills of the pre-service science teachers
3.) Science teaching efficacy belief of the pre-service science teachers

Each part contains 20 questions with 10 positive scoring of strongly agree = 4, agree = 3, disagree = 2, strongly disagree =1, while the remaining 10 has reverse scoring such as strongly disagree = 4, disagree= 3, agree= 2 and strongly   agree =1respectively. The instrument was subjected to a content validity with the help of experts in measurement and evaluation in the college. The questionnaire was administered on 100 non-participating pre-service science teachers in the College of Education, Ikere-Ekiti, Nigeria in order to determine the reliability of the instrument. It has a reliability coefficient of 0.85, which was considered reliable for the study.

The participants were an intact class of NCE part III pre-service science teachers from the school of science, College of Education, Ikere-Ekiti, Nigeria. However, a total of two hundred and sixty nine (269) pre-service science teachers made up of (119) males and one hundred (150) females representing different combinations in the school of science. The purpose of their selection was based on their enrolment in the teaching practice which is their real teaching experience outside the school for 2015/2016 session. The administration of the questionnaire took about 25 -30 minutes during the teaching practice orientation for 2015/2016 session where the participants were given the self-report questionnaire to complete.

Data Analysis

The data collected were subjected to descriptive statistics, Pearson's correlation coefficients and multivariate analysis of variance (MANOVA). In addition, the relationships among the three characteristics of pre-service science teachers were tested through hypothesizing a model depicting the casual relationships among science literacy, science process skills and science teaching efficacy belief.

In this model, the following hypothesized paths were tested to determine if
a) Science literacy has direct effect on science teaching efficacy belief;
b) If science process skills has direct effect on science teaching efficacy belief;
c) If science literacy mediates the effect of science process skills on science teaching efficacy belief; and
d) If science process skills mediates the effects of science literacy on science teaching efficacy belief.

Both models consist of one intervening variable and two internal variables. For model 1, the intervening variable is science literacy while the internal variables are science process skills and science teaching efficacy belief. However for model 2, the intervening variable is process skills whereas, the internal variables are science literacy and science teaching efficacy belief.

The models were estimated using the analysis of variance (ANOVA), the evaluation of the two models were based on t-tests of specific path coefficients and the square multiple correlation of the models to determine whether each of the hypothesized relationships has been confirmed. Prior to the path analysis, the variables were screened for deviation and normality. There was no concern about deviation from normality.

Results and Discussion

Results showed that, on average, the participants reported relatively high teaching efficacy beliefs level (M=8.24, SD=1.98) and science literacy (M=6.74, SD=1.03). Moreover, the participants reported low level of science process skills (M=3.26, SD=0.71). Next, the level of these three constructs was examined with pre-service teachers from various study majors. The multivariate analysis of variance showed an overall significant difference on the three constructs among the study programs (Wilks' lambda=0.84, F =1.91, p=0.012). Table 1 presents the follow-up one-way ANOVA for each construct by the study programs. As seen in Table 2, there were no statistical differences among the study programs on science literacy, science process skills and teaching efficacy beliefs.

Table 1: Follow-up one-way ANOVA for the three pre-service teachers' dependent variables by the study programs

Dependent	Independent	Sum of Square	df	Mean Square	F	P-value
SL	Study program	37.99	5	7.60	2.67	0.094
	Error	721.54	253	2.85		
TEB	Study program	17.55	5	3.51	2.39	0.165
	Error	370.62	253	1.47		
SPS	Study program	7.09	5	1.42	2.09	0.640
	Error	172.43	253	0.68		

SL= Science Literacy, TEB= Teachers' Efficacy Belief, SPS= Science Process Skills

Table 2: Follow-up one-way ANOVA for the three pre-service teachers' dependent variables by gender

Dependent Variables	Males	Females	df1	df2	F	P-value
SL	15.31	15.95	1	245	13.62	0.00
TEB	17.22	17.09	1	245	0.76	0.55
SPS	12.20	12.22	1	245	0.39	0.76

SL= Science Literacy, TEB= Teachers' Efficacy Belief, SPS= Science Process Skills

Table 3: Pearson product-moment correlation for the three dependent variables

Variables	SL	TEB
SL	-	
TEB	0.307*	-
SPS	-0.257*	-5.40*

SL= Science Literacy, TEB= Teachers' Efficacy Belief, SPS= Science Process Skills
*$p < 0.005$

Table 4: Effects and their t-test for various paths in the two models

Model	Cause	Effect	Direct Effect	Indirect Effect	Total Effect
Model 1	SPS SL SL	TEB TEB SPS	-0.49　　(10.17) 0.18 (3.71)　　- 0.26 (4.67)	0.13 (4.24) -	-0.49　(10.17) 0.31　(5.66)　　- 0.26 (4.67)
Model	SPS SL SPS	TEB TEB　　SL	-0.49 (10.17)　0.18 (3.71)　　　-0.26 (4.67)	-0.05 (2.90)	-0.54　(11.26) 0.18 (3.71)　　- 0.26 (4.67)

SL= Science Literacy, TEB= Teachers' Efficacy Belief, SPS= Science Process Skills
Values in parenthesis are t-test value.

Furthermore, the multivariate analysis of variance showed that the pre-service male teachers differed significantly from the pre-service female teachers on the overall effect of the three constructs (Wilks' lambda=0.85, F3, 245=2.60, p=0.005). The follow-up ANOVA analysis, in Table 2, revealed that the males and females pre-service teachers differed significantly only on their science literacy. Female pre-service teachers (M=15.95) had better science literacy than their male counterparts (M=15.31).

An investigation of the Pearson correlations, shown in Table 3, displayed intercorrelations pattern among the three constructs. Science literacy was positively correlated with teaching efficacy beliefs. This reveals that the pre-service teachers who have high positive science literacy tend to show high teaching efficacy beliefs. Moreover, science process skills had negative correlations with both science literacy and teaching efficacy beliefs. This indicates that pre-service teachers who are skillful in science process demonstrate negative science literacy and have most probably low teaching efficacy beliefs.

Table 4 displays results of the two path analysis models of science literacy, science process skills and teaching efficacy beliefs. With Model 1 where science literacy was the exogenous variable, there was a statistically significant negative direct effect of science literacy on science process skills (ɣ = -0.26, $t = 4.67$) and a positive direct effect on teaching efficacy beliefs (ɣ = 0.18, $t = 3.71$), indicating that manipulating

instruction and activities in teacher preparation programs that foster science literacy tends to reduce science process skills and improve teaching efficacy beliefs. At the same time, science literacy has an indirect effect on teaching efficacy beliefs through science process skills. This indirect effect is about the same as its corresponding direct effect ($ɤ$ = 0.13, t = 4.24). In addition, as predicted, science process skills has a statistically significant negative direct effect on teaching efficacy beliefs ($ɤ$ = -0.49, t = 10.17), suggesting that pre-service teachers with a low science process skills tends to have high teaching efficacy beliefs. This model suggests that the total effect on teaching efficacy beliefs was -0.49 which resulted from manipulating science process skills and 0.31 which resulted from manipulating science literacy.

In contrast, with Model 2 where science process skills was the exogenous variable, there was a statistically significant negative direct effect of science process skills on both science literacy ($ɤ$ =-0.26 t = 4.67) and teaching efficacy beliefs ($ɤ$ = -0.49, t = 10.17), indicating that manipulating instruction and activities in teacher preparation programs such as micro teaching that reduce science process skills tends to foster high levels of science literacy and teaching efficacy beliefs. At the same time, science process skills have an indirect effect on teaching efficacy beliefs through science literacy. However, this indirect effect is much weaker than its corresponding direct effect ($ɤ$ = -0.05, t =2.90). In addition, as predicted, science literacy has a statistically significant positive direct effect on teaching efficacy beliefs ($ɤ$ = 0.18, t = 3.71), suggesting that pre-service teachers with a high science literacy tends to have high teaching efficacy beliefs. In summary, this model suggests that the total effect on teaching efficacy beliefs was -0.54 which resulted from manipulating science process skills and 0.18 which resulted from manipulating science literacy. In summary, comparison between the two models revealed that Model 1 showed stronger total effects on teaching efficacy beliefs which resulted from both science literacy and science process skills.

Conclusion

Pre-service teachers at beginning of teaching practice showed high teaching efficacy beliefs, moderate literacy toward science as a science teacher and low science process skills. No significant differences among pre-service teachers' study programs on the three affective variables were found. These high levels of efficacy beliefs reported by our participants may and may not reflect the actual levels of teaching competence. Moderate relationships among the three pre-service teachers' affective variables were found. The Strongest relationship appeared between teaching efficacy beliefs and science process skills. The model in which science literacy was the predictor of both science process skills and teaching efficacy beliefs seems to be more supported by the current data. Hence, to promote teaching efficacy beliefs with pre-service teachers, it is advisable to design teacher preparation programs that aim to build positive science literacy in the first hand as well as science process skills. This is because science literacy affects teaching efficacy beliefs directly and indirectly affecting science process skills which by it elevate teaching efficacy beliefs.

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