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ORIGINAL ARTICLE

EXAMINING THE PSYCHOMETRIC PROPERTIES OF THE SCIENCE TEACHING EFFICACY BELIEFS INSTRUMENT AMONG NIGERIAN PRESERVICE BASIC SCIENCE TEACHERS

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Abstract:

This study investigated the psychometric properties of the science teaching efficacy beliefs instrument in a sample of 340 Nigerian preservice basic science teachers from three different universities within the blueprint of a survey research design. Responses of the participants to the Science Teaching Efficacy Belief Instrument (STEBI-B) were analysed using the classical test theory involving the principal components extraction with orthogonal rotation and this supported the factor structure of the science teaching efficacy beliefs in the collectivist culture context. The result of two-factor model is in agreement with those from previous studies and the two factors accounted for 47.32% of the total variance. The findings suggest that science teaching efficacy beliefs construct as measured by STEBI-B, appears to be culturally and contextually invariant. Future research in Nigeria should focus on confirming higher order factor structure findings (e.g., confirmatory factor analysis), to assess the stability of these factors across different samples and groups within science education settings.

KEYWORDS:

Preservice basic science teachers, Science Teaching Efficacy Beliefs Instrument, Psychometric properties

INTRODUCTION

The contribution of science to the economic wellbeing and prosperity of human race cannot be underestimated. Science is a tool for discovery and for making public-policy decisions about complex issues (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). This demands that the teaching of science be effectively done in the schools in order for citizens to be scientifically literate to make informed decisions. In Nigeria Basic science was introduced into the primary and junior secondary school curriculum in September 2008 (Awofala & Sopekan, 2013) as a replacement for the old integrated science curriculum following the full implementation of the new nine-year basic education curriculum. This change in curriculum was partly necessitated by some gaps noticed in the old curriculum and the need to make the curriculum more responsive to the needs and aspirations of the Nigerian people (Awofala, Olaoluwa & Fatade, 2013; Awofala, 2012; Awofala, Ola-Oluwa, & Fatade, 2012).

The need for a comprehensive science teacher education programme has been reinforced (Koballa & Glynn, 2007) especially in Nigeria (Afuwape, 2012) following the reform in school curricula (Awofala & Awolola, 2011a; Awofala & Awolola, 2011b). To a novice teacher, feeling confidence in one's ability to teach science successfully in the classroom is a vital aim (Scharmann, & Orth Hampton, 1995) and the lack of confidence in science teaching self-efficacy belief makes teachers less likely to teach science (Ramey-

Gassert & Shroyer, 1992). Self-efficacy beliefs as a psychological construct defined as one's beliefs about personal capabilities for successfully executing the courses of action needed to produce outcomes (Akinsola & Awofala, 2009; Savran, 2002; Bandura, 1997) is grounded in the social learning theory propounded by Bandura (1981, 1977). According to Bandura (1982), behaviour is based on two factors. First, an individual develops a generalised expectancy about action outcome contingencies based upon life experiences, or outcome expectancy. Second, he/she develops specific beliefs about his/her own ability to cope, or self-efficacy. Bandura (1982) maintained that human behaviour may be predicted by examining self-efficacy using the two expectancy factors. To him, people having both high outcome expectancy and personal efficacy will behave in an assured, decided manner and persist on task whereas people with both low outcome expectancy and high personal efficacy temporarily intensify their efforts, but will eventually have frustration.

The assessment of self-efficacy and outcome expectancy in relation to teaching has been the focus of research by many researchers (Ashton & Webb, 1986; Enochs & Riggs, 1990; Gibson & Dembo, 1984; Guskey, 1988; Woolfolk & Hoy, 1990) with two strands of research identified (Tschannen-Moran, Hoy, & Hoy, 1998). The first strand of research is anchored on Rotter's social learning theory of internal versus external control (Rotter, 1996). Teachers who believe that they have the ability and are effective to teach difficult or unmotivated students were termed to have internal control whereas teachers who attribute students' learning to the influence of the environment rather than their own teaching abilities were termed to have external control. Based on this locus of control orientation, rand researchers (Armor et al., 1976; Berman, McLaughlin, Bass, Pauly, & Zellman, 1977) have studied teacher efficacy using only two items (Item 1: “When it comes right down to it, a teacher really cannot do much because most of a student's motivation and performance depends on his or her home environment.”; Item 2: “If I really try hard, I can get through to even the most difficult or unmotivated students.”). Teachers who agree with item 1 have beliefs about the power of external factors which are largely environmental such as the conflict, violence, or substance abuse in the home or community; the value placed on education at home; the social and economic realities concerning class, race, and gender; and the physiological, emotional and cognitive needs of a particular child in overwhelming their efforts on students' learning are termed to possess the General Teaching Efficacy (GTE). Teachers who agree with item 2 have confidence in their abilities to overwhelm any factors which make learning difficult for a student and such teachers are making a statement about their own efficacy in teaching, and reflecting a confidence in the adequacy of their training or experience in developing strategies to overcome any obstacles in student learning. In this regard such teachers are termed to possess the Personal Teaching Efficacy (PTE) which is more specific when compared to the General Teaching Efficacy. Other instruments developed to measure efficacy in the Rand/Rotter tradition include the Teacher Locus of Control (TLC) (Rose & Medway, 1981), the Responsibility for Student Achievement (RSA) (Guskey, 1981), and the Webb Efficacy Scale (Ashton, Olejnik, Crocker & McAuliffe, 1982).

The second strand of research on teacher efficacy is anchored on the Bandura's social cognitive theory and his construct of self-efficacy (Bandura, 1997, 1977) and many instruments have been developed in line with this theory to include the Teacher Efficacy Scale (Gibson & Dembo, 1984), The Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990), the Ashton Vignettes (Ashton, Buhr & Crocker, 1984), and the Teacher Self Efficacy Scale (Bandura, Undated). Ashton, Webb and Doda (1983) interpreted teachers' sense of efficacy by proposing a model which consisted of teaching efficacy, personal efficacy, and personal teaching efficacy. Teaching efficacy referred to a teacher's belief about the general relationship between teaching and learning and it appears to be similar to Bandura's outcome expectancy. Personal efficacy referred to a teacher's general sense of his/her own effectiveness not specific to a particular situation. Personal teaching efficacy was considered to be a combination of teaching efficacy and personal efficacy. Since self-efficacy belief influences elementary science instruction (Aydin & Boz, 2010), then a dependable instrument that can measure science teaching efficacy beliefs should be valuable for evaluating the effectiveness of science teacher education programme aimed at making citizens scientifically literate to make informed decisions.

Bandura (1977) emphasized that self-efficacy was most appropriately measured in specific contexts. The subject matter Science Teaching Efficacy Beliefs Instrument (STEBI) is an instrument developed in 1990 (Riggs & Enochs, 1990; Enochs & Riggs, 1990) based on Bandura's self-efficacy theory. The STEBI has two versions; the Science Teaching Efficacy Belief Instrument form A (STEBI-A) for inservice elementary teachers (Riggs & Enochs, 1990) and the Science Teaching Efficacy Belief Instrument form B (STEBI-B) for preservice elementary teachers (Enochs & Riggs, 1990). The STEBI-A was developed first with 25 items based on the Gibson's and Dembo's (1984) instrument (TES) and also consisted of two largely uncorrelated subscales: Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). According to Enochs and Riggs (1990) early detection of low self-efficacy in elementary science teaching is critical to any teacher preparation programme. The STEBI-B was developed from the modified STEBI-A dropping two of the original items and modifying the verb tenses in the items to reflect the future orientation to teaching of preservice teachers. The STEBI-B is a 23- item instrument anchored on a five-point Likert scale, ranging from strongly agree to strongly disagree.

Several researchers have used the STEBI-B to investigate issues of self-efficacy in preservice elementary science teachers and in relation to other affective and cognitive measures. Schoon and Boone (1998) investigated the relationship between preservice elementary science teachers' (n=619) self-efficacy beliefs and their alternative conceptions. Results revealed that preservice teachers who got higher scores in the achievement test had a tendency to get high Personal Science Teaching Self-efficacy (PSTE) score from STEBI-B. Similarly, the relation between preservice elementary science teachers' (n = 299) understanding of science and self-efficacy in science teaching was examined by Tekkaya, et al., (2002) using the STEBI-B and Science Concept Test (SCT). Results showed that SCT scores were low whereas their teaching self-efficacy beliefs were high in both subscales of PSTE and STOE.

Çakıroğlu and Çakıroğlu (2003) compared preservice elementary teachers' sense of efficacy beliefs in a Turkish university, and in a major Midwest university in USA using Science Teaching Efficacy Belief Instrument (STEBI-B). Results showed that the preservice teachers indicated generally positive self-efficacy beliefs regarding science teaching in both countries. In both countries, science courses completed in high school and college did not appear to have influence on subjects' self-efficacy beliefs regarding science teaching. The results also indicated that the preservice elementary teachers in USA had significantly higher personal science teaching efficacy scores than the preservice elementary teachers in Turkey. On the other hand, science teacher outcome expectancy scores of the preservice teachers from the two countries were not significantly different. Moreover, Enochs, et al., (1995) studied 73 pre-service elementary teachers, who were at the last semester of teacher education programme using the STEBI-B and Pupil Control Ideology (PCI) instruments. Results revealed that teachers with high self-efficacy had a tendency to adopt humanistic orientation for classroom management.

Another study about the relation between teachers' self-efficacy beliefs and their class management orientations was carried out by Gencer and Cakiroglu (2007). STEBI-B and Turkish version of Attitudes and Beliefs on Class Control (ABCC) inventory were utilized. No significant differences between neither gender nor grade in terms of self-efficacy beliefs and classroom management orientations were found. Additionally, positive correlations were found between PSTE scores and instructional management scores of participants, and between STOE and instructional management. However, a significant negative correlation was found between PSTE and people management. In addition to class management orientations, attitude toward teaching was another variable whose relation with self-efficacy of teachers was investigated.

To investigate pre-service elementary science teachers' scientific knowledge, attitude toward science teaching and self-efficacy beliefs in science teaching, Sarikaya (2004) administered three instruments to 750 pre-service teachers. STEBIB for self-efficacy, Science Achievement Test (SAT) for scientific knowledge and Science Teaching Attitude Scale (SCAT) for teaching attitude were used. Results revealed that participants' self-efficacy beliefs in science teaching were moderate. Moreover, there was no significant difference between males and females on the both PSTE and STOE. Additionally, there was a significant positive correlation between PSTE and the number of pedagogical courses taken. Results of the Multiple Regression Correlation (MRC) indicated that science knowledge and attitude toward science teaching were significant predictors of PSTE. The model including science achievement and attitude explained 40% of the variation in PSTE. For STOE, 4% of the variance was explained by the model and each variable had significant contribution to the variance in STOE. Huinker and Madison (1997) investigated the impact of methods courses on preservice elementary teachers' personal efficacy beliefs and outcome expectancy beliefs in science and mathematics teaching. A pretest-posttest one-group research design was used each semester to collect quantitative data from 62 preservice elementary teachers throughout the use of two teaching efficacy beliefs instruments, one for science (STEBI-B) and one for mathematics (the Mathematics Teaching Efficacy Beliefs Instrument-MTEBI-). A series of individual interviews were conducted with a sample of subjects to gather qualitative data. They found that both science and mathematics methods course consistently had a positive influence on the preservice elementary teachers' beliefs in their ability to teach science and mathematics effectively.

Similarly, Morrell and Carroll (2002) examined the impact of science methods courses, student teaching and science content courses an elementary preservice teachers' science teaching self-efficacy using the STEBI-B at the beginning and end of each course included in the study. Results showed that the methods course positively impacted the elementary preservice teachers' PSTE and the scores on this scale significantly increased over the duration of each methods course. Aydin and Boz (2010) measured the science teaching self-efficacy beliefs and also determined whether there was a difference between the grades of pre-service science teachers in terms of self-efficacy in science teaching as well as sources of their self-efficacy beliefs using the STEBI-B on a sample of 492 preservice elementary science teachers. Results showed that self-efficacy beliefs of preservice teachers were generally high for both subscales that are Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). Moreover, Multivariate Analysis of Variance (MANOVA) showed that the preservice teachers in the final year had significantly higher self-efficacy beliefs.

Sarikaya (2004) investigated science knowledge level, attitude toward science teaching and efficacy beliefs regarding science teaching of 750 fourth-year preservice elementary teachers who enrolled at elementary teacher education programmes of nine different universities in Turkey. Data were collected using three questionnaires: the Science Teaching Efficacy Belief Instrument (STEBI-B), Science Achievement Test, and Science Teaching Attitude Scale. Analysis of the self-efficacy survey indicated that preservice elementary teachers had moderate sense of self-efficacy beliefs regarding science teaching on both Personal Science Teaching Efficacy and Outcome Expectancy dimensions of the STEBI-B. Bleicher (2004) re-examined the reliability and validity of the STEBI-B 14 years after the original development of the instrument through factor analytic study and found that the two subscales, PSTE and STOE were homogeneous and loadings were comparable to those earlier reported. Two items on the STOE were found to exhibit cross-loading on the factor analysis as well as low item-total correlations.

Based on this background, it is noted that studies that employed the STEBI-B to measure teaching confidence and outcome expectancy across different contexts and cultures assumed the reliability and validity of this instrument to be intact and Bleicher (2004) maintained that due to the repeated use of the STEBI-B it is more prudent to re-examine the psychometric properties of this instrument which is almost 23 years old now. More so, the refinement of assessment tools that increase the explanatory and predictive power of self-efficacy constructs may advance the understanding of social-cognitive processes.

THE PROBLEM

Based on the background to this study, we re-examined the factor analytic structure supporting the original two subscales represented in the STEBI-B (i.e., personal science teaching self-efficacy and outcome expectancy). Specifically, the following research questions are addressed:

Research Question One: What is the empirical factor structure of the science teaching efficacy beliefs (STEBI-B) items?

Research Question Two: What are the internal consistency reliabilities of the STEBI-B subscales?

SCOPE AND LIMITATION OF THE STUDY

1. The study is limited to 340 preservice basic science teachers in three universities in South West Nigeria.
2. Topical Scope: The topical scope is limited to the re-examination of the factor analytic structure supporting the original two subscales represented in the STEBI-B (i.e., personal science teaching self-efficacy and outcome expectancy).
3. Analytical scope: The analytical scope is limited to the answering of the two research questions for the study.
4. The results are dependent upon data collected with the study instrument and analysed by principal components extraction with orthogonal rotation.

METHODOLOGY

PARTICIPANTS

The participants for this study were 340 preservice basic science teachers (142 males and 198 females) who were enrolled in three different public universities in South West Nigeria and the whole were seniors being ready to be teachers in junior secondary schools. Altogether their ages ranged between 19 and 31 years (M=23.3, SD = 2.5).

INSTRUMENT

The present study used one instrument: Science Teaching Efficacy Belief Instrument (STEBI-B). The Science Teaching Efficacy Belief Instrument (STEBI-B) was developed by Enochs and Riggs in 1990 to measure preservice elementary teacher's self-efficacy beliefs toward science teaching. The STEBI-B consists of 23 items in a five- point Likert type scale ranging from strongly agree to strongly disagree and has two subscales; Personal Science Teaching Efficacy (PSTE) including 13 items and Science Teaching

Outcome Expectancy (STOE) including 10 items. The instrument has been used widely in different settings and found reliable and valid (Aydin & Boz, 2010; Wingfiled, Freeman & Ramsey, 2000; Bleicher, 2001, 2002; Bleicher & Lindgren, 2002). The STEBI-B was amended to reflect a four-point scale in the present study.

PROCEDURE

The STEBI-B was administered to the preservice teachers by the researcher in company of two trained research assistants who visited the classrooms to apply the instrument to the students in the three universities.

RESULTS

In the present study the internal consistency reliabilities for the subscales were: PSTE (α = .82) and STOE (α = .79) and the internal consistency reliability for the entire scale (α = .90) was considered very high and conceptually meaningful (Curtis & Singh, 1997). Thus, the two measures represent empirically separable and internally consistent self-efficacy beliefs constructs. To ascertain the structure of the 23 items STEBI-B, (common) factors were extracted using the principal components factor analyses (PCA) with varimax rotation. Initial inspection of the correlation matrix of the 23 items revealed that the correlations when taken overall were statistically significant as indicated by the Bartlett's test of sphericity, $\chi 2$ = 13208.89; df=65; p<.001 which tests the null hypothesis that the correlation matrix is an identity matrix. The Kaiser- Meyer- Olkin measure of sampling adequacy (MSA) fell within acceptable range (values of .60 and above) with a value of .706. Each of the variables also exceeded the threshold value (.60) of MSA which ranged from .646 to .852. Finally, most of the partial correlations were small as indicated by the anti-image correlation matrix. These measures all led to the conclusion that the set of 23 items of STEBI-B was appropriate for PCA. The initial pre-rotation resulted in two factors with eigenvalues greater than 1 (Kaiser, 1960; Tabachnick & Fidell, 2007), accounting for approximately 45% and based on its pattern of factor loadings, this unrotated factor model was theoretically less meaningful and as such was difficult to interpret. Therefore, the analysis proceeded to rotate the factor matrix orthogonally to achieve a simple and theoretically more meaningful solution. Varimax rotation was used for the orthogonal solution. By rotating two factors, the total percentage of variance accounted for increased to approximately 47%. An examination of Scree test produced two-factor solution (Figure 1).This seemed to support the original theory on which the instrument is based which had proposed two factors. For interpretational clarity, a salient loading (Gorsuch, 1983, p. 208) of 0.40 was selected as one that is sufficiently high to assume the existence of an item-factor relationship. The first factor, which accounted for 35.34% of the variance (eigenvalue=8.129), was labelled Personal Science Teaching Efficacy (PSTE) and this factor included 13 items. The second factor, Science Teaching Outcome Expectancy (STOE) included 10 items and accounted for 11.980% of the variance (eigenvalue=2.755). The PSTE were positively related to STOE (r = .45, p<.001).

In this study, all the communalities for the factor analysis satisfied the minimum requirement of being larger than 0.50, in fact these ranged from 0.697 to 0.952. Figure 1 below is the scree plot which graphs the eigenvalue against the component number and is suggestive of a two component model.

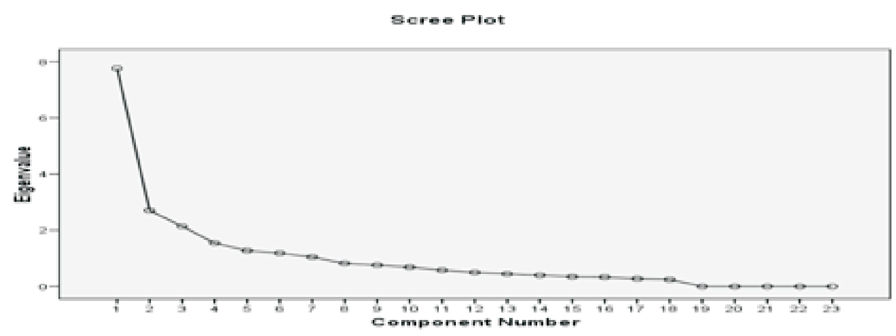

Fig. 1. Cattell scree plot showing number of components and eigenvalues of the correlation matrix.

Table 1 displays the factor loadings for the orthogonal two-factor model of STEBI-B. All items loaded .40 and above on their primary factor; none of the secondary loadings exceeded .30.

Table 1:
Summary of Factor Loadings by Principal Components Analysis for the Orthogonal Two-Factor Model of STEBI-B

Item	Factor Loadings 1	2
When a student does better than usual in science, it is often because the Teacher exerted a little extra effort		.592
When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach	.421	
If students are underachieving in science, it is most likely due to ineffective Science teaching		.413
The inadequacy of a student's science background can be overcome by good Teaching	.589	
The low science achievement of some students cannot generally be blamed on their teachers		.651
When a low- achieving child progresses in science, it is usually due to extra attention given by the teacher	.463	
Increased effort in science teaching produces little change in some students' Science achievement	.663	
The teacher is generally responsible for the achievement of students in science	.601	
Students' achievement in science is directly related to their teacher's effectiveness in science teaching	.632	
If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher	.433	
I will continually find better ways to teach science	.744	
Even if I try very hard, I will not teach science as well as I will most subjects		.766
I know the steps necessary to teach science concepts effectively	.573	
I will not be very effective in monitoring science experiments		.441
I will generally teach science ineffectively		.610
I understand science concepts well enough to be effective in teaching elementary science	.560	
I will find it difficult to explain to students why science experiments Work	.466	
I will typically be able to answer students' science questions	.924	
I wonder if I will have the necessary skills to teach science.	.460	
Given a choice, I will not invite the principal to evaluate my science teaching.	.912	
When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better.	.468	
When teaching science, I will usually welcome student questions.	.523	
I do not know what to do to turn students on to science.	.640	

Note: Factor 1 = Personal Science Teaching Efficacy (PSTE)
Factor 2 = Science Teaching Outcome Expectancy (STOE)
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

DISCUSSION

The present study provides theoretically-driven and empirically-based analyses that contribute to the body of research on psychometric properties of science teaching efficacy beliefs instrument for preservice science teachers in an entirely different context and environment. This study explored the possibility of a factor structure underlying the STEBI-B and a principal components factor analysis computed with varimax rotation supported a two-factor model of science teaching efficacy beliefs namely, Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). The theoretical implications of the STEBI-B seem to be important given the prominent role of self-efficacy beliefs in diverse lines of science education research (Bleicher, 2004; Enochs & Riggs, 1990).The two factors found in the current sample confirmed the culturally invariant nature of the STEBI-B instrument. The good internal consistency reliabilities obtained here (and in other studies) suggest that the instrument would be found quite useful for science educators in ascertaining the science teaching efficacy beliefs of their students most of whom are preservice teachers.

The generalisability of the study is limited by the inherent subjectivity of the factor-analytic process (e.g., selection of the number of factors, choice of rotation). Other researchers might provide different labels for the obtained factors. Furthermore, the demographic characteristics of the sample may be a limiting factor as pattern differences due to gender or cultural groupings were unexplored and may exist. In light of the non-academic factors uncovered here, the predictive validity of science teaching efficacy beliefs within various science domains (chemistry, physics, and biology) might also be of interest.

Finally, further research is needed in Nigeria to confirm higher order factor structure findings (e.g., confirmatory factor analysis), to assess the stability of these factors across different samples and groups within science education settings.

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