



## **Self-efficacy Factor Invariance across Pre-service and In-service Teachers in Botswana**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. All authors participated in the data collection and analysis exercise. They all read and approved the final manuscript.*

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### **ABSTRACT**

The challenges facing measurement experts and researchers in the social sciences field is ensuring that measurement scales operate equally across different sub-populations. Measurement invariance across gender for example means that males and females conceptualize and interpret the construct being measured similarly and thus meaningful comparisons between the groups can be made. Measurement non-invariance on the other hand can be a threat to validity as it implies that the construct being assessed has different structures across groups. The current study investigates the invariance of self-efficacy construct across pre-service and in-service teachers. The teachers were administered a Teacher Self Efficacy Scale with 33 Likert scale items and the data were analyzed using maximum likelihood procedures with Varimax rotation techniques. Reliable dimensions were extracted on the basis of two factor extraction procedures. The final solutions for the two groups were interpreted with reference to the factor loadings and item content for items that had significant loading on a particular factor.

*Keywords: Pre-service and in-service teachers; measurement invariance; varimax rotation; configurable invariance; eigenvalues; education and training sector strategic plan.*

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## 1. INTRODUCTION AND BACKGROUND

The quality and relevance of any educational programme is judged by the ease with which its graduates fit effectively into the world of work and are immediately productive and easily trainable. This line of thinking is captured in the recent policy thinking as encapsulated by the Education and Training Sector Strategic Plan, which was promulgated by Botswana government in 2015. According to [1], the new policy "...is intended to strengthen the match between qualifications and labour market requirements, thereby ensuring that education outputs are more closely aligned to future employment needs" (p. 6). The direct implication of this policy direction is that educational programmes should be aligned systematically to what is happening in the job market. Specifically, pre-service teachers should be given experiences that prepared them to the realities and challenges of the teaching profession. In terms of the self-efficacy construct, it is imperative that pre-service teachers exhibit self-efficacy characteristics and or attributes possessed counterpart in the field. A comparison of the self-efficacy beliefs of pre-service and in-service teachers would assist in as far as delineating salient differences and/or similarities between the groups. The differences would signal a need for intervention at the pre-service level to bring the teacher trainees up to speed with what is happening in the field. Therefore, factor analysis will be utilized to reduce the covariance matrices of the two groups so as to identify underlying dimensions that characterize the self-efficacy construct as measured by the Teacher Self Efficacy Scale (TSES); the scale was originally developed by [2].

According to [3], factor structure invariance between subpopulations can be performed at different levels (i.e., configural invariance, metric invariance, scalar invariance, and strict invariance). Under configural invariance, the analysis is done to determine the extent to which the factor patterns are consistent across groups without having to impose restrictions on the model parameters [4]. If the data supports configural invariance then an argument can be made to the effect that the factor structure is equivalent across groups. Evidence of similar factor patterns however does not guarantee that the scale is operating in the same way across groups in terms of units of measurement (metric invariance), scale origin (scalar invariance) and errors of measurement (strict invariance)

associated with each item. Configural invariance only gives the researcher an opportunity to test a series of invariance hypothesis. At each point, the no-significant chi-square difference test signals invariance and allows for testing of a more restricted models [5]. The current study, however, only addresses issues of factor structure equivalence across groups in relation to the number of extracted factors.

### 1.1 Theoretical Model

Psychological constructs such as self-efficacy are unobservable properties of the mind but they are the subject of interest for measurement experts and researchers. The fact that the constructs are intangible means that scientists can only measure them indirectly via a variety of measurement scales [6,7,8]. More often than not, a psychological instrument is composed of numerous items designed to tap on the construct of interest. The principle of construct underrepresentation [9] compels measurement experts to include as many items in the scale to ensure that a broad spectrum of the construct is covered. In the event that items in the instrument fail to cover the domain of interest well, the measurement instrument runs the risk of lacking both reliability and validity. Therefore, an instrument will usually have several items that are used to provide empirical evidence on the construct. The expectation is that the covariance between the items will provide information on the construct. Therefore, the items in a scale are thought to be a linear combination of the underlying latent variable. Factor analysis has been designed to systematically pattern the covariance amongst the items to discern systematic correlations amongst a cluster of items within a scale [10]. Though a test might have 30 separate items, what factor analysis does is to group the items according to their covariance thus reduce the number of items to fewer groups called dimensions or factors. The content of the items that have been grouped together are used to name the factor and the factor is then assumed to be the causative agent or a latent variable that influences variations in the items.

Exploratory factor analysis is an initial procedure that identifies underlying dimensions and can be utilized for theory building [11]. According to [12]:

The procedure is exploratory because, presumably, the investigator has no firm a priori expectations based on theory or prior

research about the composition of the subscales and thus the analysis is used to discover the latent variables that underlie the scale (p. 286).

Confirmatory factor analysis (CFA) on the other hand works by fitting an a priori models to a set of data and various goodness-of-fit indicators are used to judge the adequacy of fit of the model to sample data [6]. Therefore, CFA is mainly used for theory testing and construct validation [13,14].

## 1.2 Statement of the Problem

Previous research has indicated that pre-service and in-service teachers have different self-efficacy beliefs where the former are indicated with a unidimensional construct while a multidimensional model adequately fits the data for the in-service teachers. The lack of consistency in factor structure between the groups means contrasting conceptualization of the self-efficacy construct. In other works, the pre-service teachers might be having a rather simplified view of a very complex construct thus increasing the likelihood of a mismatch between their attributes and what is expected of them once they are in the field. Identification of the differences is important as proactive action could be taken to address areas of need to make sure that teacher trainees go to the field well prepared.

## 1.3 Related Works

A CFA study was conducted by [15] to determine the invariance of the Academic Motivational Scale (AMS) across gender and years. According to the researchers, "over the years, research on student motivation has flourished and remained a contemporary and important topic in education and psychology" (p. 73). CFA was seen as the most appropriate data reduction procedure because the method allows for a simultaneous analysis of two or more variables in one study. AMS was developed based on the self-determination theory; the scale comprises five sub-scales (i.e., intrinsic motivation, identified regulation, introjected regulation, external regulation, and a motivation). The items are in a Likert scale format permitting the respondent to indicate their motivation on a scale that ranges from 0 (representing the lowest level of motivation) to 4 (indicating the maximum level of motivation). The analysis followed the forward sequential release method of testing nested models starting from a model containing freely estimated parameters to a more constrained one

only if the chi-square difference test is not significant. A significant chi-square difference test is a sign that the added constraints have had a worsening effect on the constrained model when compared to the less constrained one. The data was first tested for configural invariance after which metric and scalar invariance was tested following non-significant chi-square.

The results of the study as presented by [15] indicated presence of "longitudinal cross-gender metric invariance, as well as satisfactory support for scalar invariance of the AMS" (p. 94). Since the invariance of the scale across years was not as strongly supported as the invariance across gender, this noticeable discrepancy motivated the researchers to try and pinpoint the source of possible non-invariance. The post hoc analysis revealed that the differences in the motivational level across years may be explained by the fact that boys and girls undergo different developmental characteristics with boys normally lagging behind girls. Secondly, the longitudinal test of invariance for girls was more homogeneous in relation to the construct of interest as opposed to longitudinal test of invariance for boys. This appeared to be an interesting topic for future research and theory development.

According to [4], "Student achievement is considered an indicator of the quality of education, and achievement tests are applied to assess student achievement" (389). A variety of international tests have been used over the years to measure learner achievement in different countries. Examples of these tests include Monitoring Learning Achievement (MLA), Southern and Eastern Africa Countries Consortium for Monitoring Educational Quality (SACMEQ), and Trends in International Mathematics and Science Study (TIMSS). TIMSS-a branch of the International Association for the Evaluation of Educational Achievement (IEA)-is a comparative study that is run periodically in over 60 countries worldwide. The main purpose of the comparative studies is generation of high quality diagnostic information that allows each participating country to make evidence-based intervention strategies aimed at improving learning and teaching. Due to its international perspective, TIMSS researchers have to carry-out research work that covers a broad spectrum of countries with contrasting cultural, political as well as economic characteristics. This situation compelled TIMSS researchers to translate their instruments to fit

unique characteristics of each country without necessarily modifying the construct being targeted by each instrument. The challenge, therefore, is provision of empirical evidence in support of the invariance of TIMSS across countries. Measurement invariance will be achieved when examinees (i.e., from different countries) having the same ability with respect to the construct of interest produce a comparable score on the test. A comparable score in this case is an indication that examinees in different countries interpret the construct in the same way and as such their scores can be compared.

To assess the measurement invariance of TIMSS across different populations, [4] used the TIMSS data for 2011. The main objective of the study therefore, was to test the TIMSS mathematics scores for measurement invariance across four countries, namely Turkey, England, Japan, and the USA. The four countries were included in the sample because of their contrasting cultural and language characteristics. Purposive sampling was used to select a total of 1987 fourth grade learners in the four participating countries.

The sequential constraint imposition Multiple-Group Confirmatory Factor Analysis (MG-CFA) approach [16] was used to test a series of nested models using LISREL version 8.80. Multiple goodness-of-fit statistics were applied to the non-invariance hypothesis (e.g., root mean square error of approximation (RMSEA), comparative fit index (CFA), goodness of fit index (GFI), root mean square residual (RMR), non-normed fit index (NNFI), Chi-square difference test). The measurement model that was fit to the TIMSS observed data comprised three first level factors (Knowledge, Reasoning, and Application) with each factor measured by several metric variables. The result of the study indicated good fit of the measurement model to the TIMSS data, [16] concluded by stating that "...it can be said that the proposed model was confirmed for all countries and the configural invariance, which is the first step of measurement invariance, was ensured" (p. 398). The non-significance of the chi-square differences test allowed the researchers to test the data for metric invariance, scalar invariance and residual invariance. Metric invariance required fixing of the factor loadings to be equal across countries. Since the metric invariance model is nested within the configural model, the chi-square difference test was relied upon as a basis for either rejecting or retaining the measurement non-invariance hypothesis. At

this level of the analysis, the chi-square difference test was significant thus indicating that adding more constraints to the configural model lead to the worsening of model. In other words, the metric invariance model which was used to examine whether learners in different countries responded to the TIMSS items in the same way did not hold across countries indicating that:

...the relationship between characteristic measured and the dimensions of the scale are not similar. In this situation, it can be expressed that the countries did not respond to the items in a similar manner, and making comparison between these scores obtained from these groups is not meaningful" (p 399).

The retention of the non-invariance hypothesis meant that further analysis to test for scalar and residual invariance could not be conducted. However, the researchers were interested to identify the country within which metric invariance was not upheld. A post hoc analysis using binary and trilateral combination of participating countries also failed to locate the offending country. The overall conclusion was that learners in the four countries interpreted the items differently thus possibly affecting the generalizability of the TIMSS scale.

Another study was conducted by [17] entitled "Exploring the validity of a teachers' self-efficacy scale in five countries." The objective of the paper was to determine the factor structure invariance of the short form of the Teacher self-Efficacy scale across teachers in North America, Canada, Cyprus, Korea, and Singapore. The researchers were motivated by the belief that "...measures of psychological construct cannot simply be translated into another language with the assumption that they can be interpreted in the same way across groups" (p. 69).

To test the hypothesis of factor structure invariance across groups, the researchers applied multigroup confirmatory factor analysis (MG-CFA) in combination with several goodness-of-fit indicators to select the best fitting model. However, the difference in the comparative fit index ( $\Delta CFI$ ) was given more weight because it is less sensitive to sample size [17]. A series of nested CFA models were sequentially tested starting with the less constrained model where parameters were allowed to freely vary between groups. To establish the best fitting baseline model, the one-factor self-efficacy model was compared to the three-factor model; the latter

model explains self-efficacy construct in terms of three factor which have been named as self-efficacy for classroom management, self-efficacy for instructional effectiveness, and self-efficacy for learner engagement. The results indicated that the three factor model was a significant improvement over the one-factor model and the fit statistics were within acceptable range [17]. The three-factor base line model was then tested for invariance across the five countries simultaneously using CFA modeling procedures. The researchers first tested the model for equality of the factor patterns across the five countries to establish configural invariance. Configural invariance hypothesis was retained. Retention of the configural invariance hypothesis allowed the researchers to add more parameters constraints to the model. Subsequently, the researchers tested for equality of the factor loadings and variance covariance matrix. Though the chi-square difference test was significant in both cases (i.e., metric and structural invariance), the  $\Delta$ CFI values provided supported for metric as well as structural invariance across the five countries. The findings led [17] to conclude that:

...TSES showed convincing evidence of invariance of factor forms, factor loadings, and factor variances and covariance across groups of teachers within culturally similar regions in North America and East Asia, and across six groups of teachers from five countries in North America, East Asia, and Europe. (p. 73)

It can be concluded that the study by [17] provides additional evidence to the structural validity as well as the generalizability of the TSES.

## 2. METHODOLOGY

The study is essentially quantitative in nature. A survey inferential design was used to analyze metric variables obtained from the TSES. The study used two different target populations, i.e., pre-service and in-service teachers. The in-service sample was obtained from students who registered for a Post Graduate Diploma in Education (PGDE) at the University of Botswana in the 2015 to 2016 academic year. Simple random sampling was applied to select a total of 110 participants. The students responded to the Self-Efficacy scale. The second target population of the study comprised in-service teachers in Botswana; a total of 1000 junior secondary school teachers responded to a TSES. The data

was collected in 2012 from junior secondary schools in South East, Kgatleng and Kweneng districts. Stratified sampling procedures were used to select 300 teachers with varying teaching experience (i.e., 100 teachers with three years teaching experience or less, 100 teachers with four to seven years teaching experience, and 100 teachers with eight years teaching experience or more).

## 3. DATA ANALYSIS

The scores from the two samples (e.g., in-service and pre-service) were factor analysed using exploratory factor analysis techniques with Varimax rotation to extract factors that account for largest amount of variance in the matrix.

### 3.1 Pre-service Factor Structure

The pre-service data was analysed first as a way of establishing a baseline. Table 1 shows the factor structure for the pre-service (PGDE) group. Two factors in the table satisfied the Eigenvalue greater than one rule [18]; however, the second factor is only marginally significant.

The second piece of evidence that provides additional information on the number of factors to extract is presented in the scree plot [19]. The scree plot depicted in Fig. 1 shows that the variance in the data is mainly accounted for by the first factor (i.e., 48.26), the second factor only accounts for 9.07% of the variance and its marginal status is reflected by the fact that it is along the same horizontal line with the rest of the no-significant factors. This strongly suggests retention of only one factor. The unidimensional factor structure for the pre-service teachers is consistent with previous research studies.

Another self-efficacy research was done by [20], the two researchers did an EFA on data from 270 mi-Atlantic pre-service teachers in the USA; the teachers responded to a Teacher Self-Efficacy Scale. Subsequent analysis of the data indicted a one-factor solution as the most parsimonious solution. In 2016, [21] replicated Fives and Buehl study by administering the TSES to 589 teacher-trainees upon which EFA with Varimax rotation also indicated a unidimensional factor structure. It is interesting to note that although the two studies were based in two different countries (i.e., USA and Botswana), the findings were similar. Botswana is still described as a developing country with an economy that is dominated by the mining sector and subsistent

agricultural production. The USA on the other hand, has a fully developed first-world economy that is characterized by high standard of living for the citizens. The expectation was that teachers operating within these contrasting social conditions would exhibit different characteristics.

### 3.2 In-service Teacher Factor Structure

In 2012, a total of 1000 junior secondary schools completed the self-efficacy scale; 300 questionnaires were randomly sampled from this pool for further analysis. This sample was divided into three groups; the first group was for teachers with up to three years of teaching experience, the second group was for teachers with four to seven years' experience while the last group had more than seven years teaching experience. Fig. 2 and Fig. 3 show the scree plots for the first two groups of teachers (e.g., teachers with up to four years of teaching and those with up to seven years of teaching experience). It is evident that these groups of teachers have a factor structure that is similar to the pre-service cohort. Though it can be argued that there is some evidence of a

second factor emerging in Fig. 2, there is no clear and unambiguous distinction between the second and third factor thus putting the psychometric reliability of the second factor into question.

However, both Fig. 2 and Fig. 3 clearly indicate the non-existence of the third factor in the data for teachers with up to three years of teaching experience and those who have been in the field for seven years or less. The most plausible conclusion for these two groups is to postulate a unidimensional structure as the most meaningful.

The situation for teachers with more than seven years in the field is markedly different. Table 2 shows that the first, second and third factors account for 42.56%, 11.22%, and 10.58% of the variance in the scale respectively. Therefore, data for practicing teachers with teaching experience of more than seven years has led to the retention of three factors that collectively account for 64.35% of the variance in the correlation matrix. Secondly, the scree plot (Fig. 4) has a clear point of inflection between the

Table 1. Pre-service data

Component	Total variance explained								
	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.791	48.258	48.258	5.791	48.258	48.258	4.210	35.080	35.080
2	1.089	9.075	57.333	1.089	9.075	57.333	2.670	22.254	57.333
	.844	7.033	64.366						

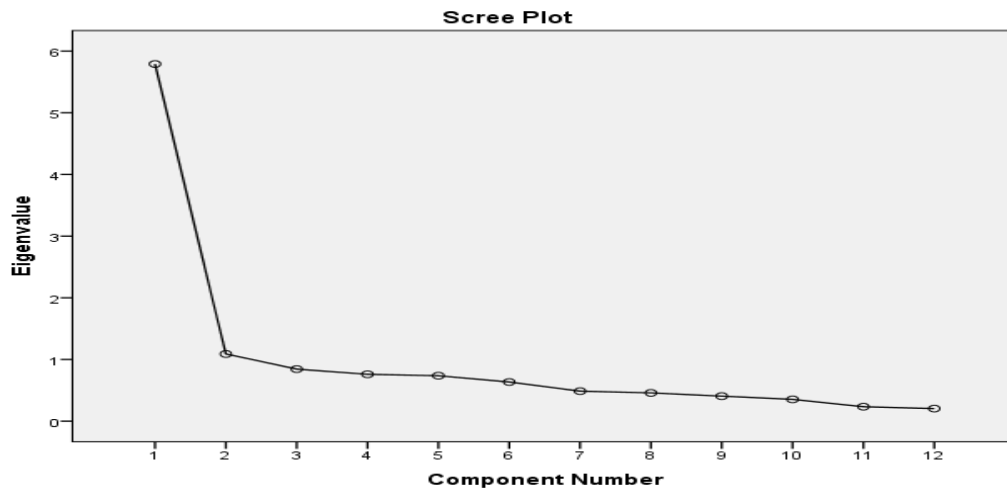


Fig. 1. Pre-service teachers' scree plot

third factor and the fourth factor thus making it easier to separate reliable dimensions from trivial ones. These results not only attest to the construct validity of the TSES but also provide solid empirical evidence that shows that pre-

service and in-service teachers have different self-efficacy believes. Suffice to mention at this juncture that the difference between pre-service and in-service teachers is explained to a large extent by teaching experience.

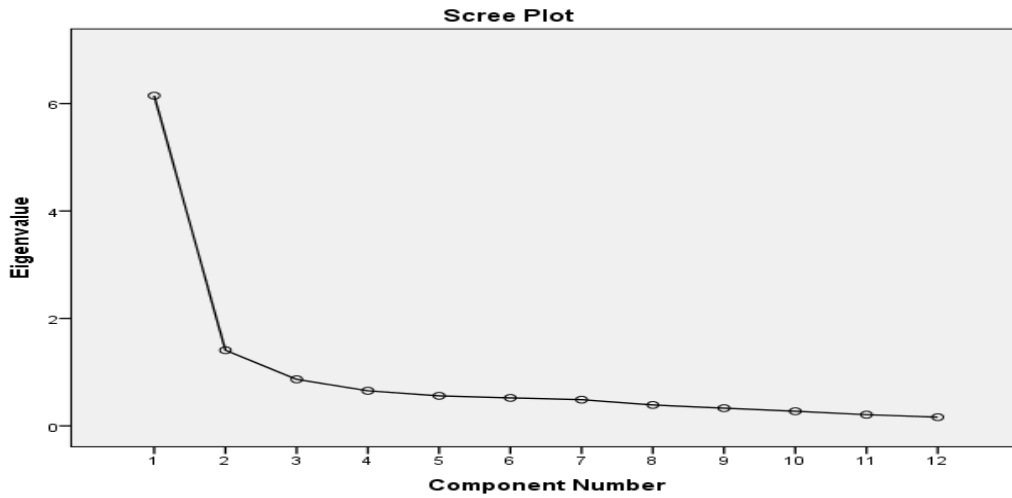


Fig. 2. Scree plot for teachers with up to three years of teaching experience

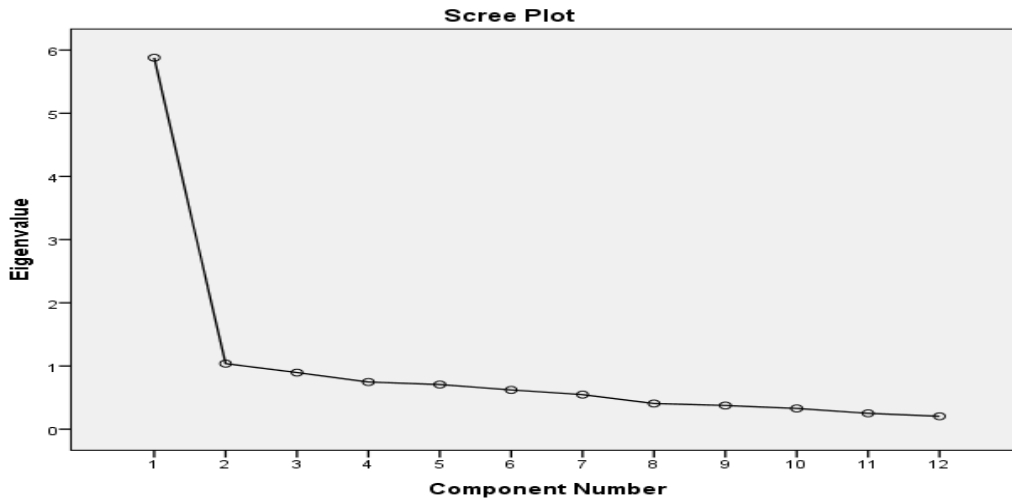


Fig. 3 Scree plot for teachers with 4 to 7 years teaching experience

Table 2. Analysis on data from teachers with more than 7 years teaching experience

Component	Total variance explained								
	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.107	42.559	42.559	5.107	42.559	42.559	2.841	23.676	23.676
2	1.346	11.216	53.775	1.346	11.216	53.775	2.732	22.770	46.447
3	1.269	10.577	64.352	1.269	10.577	64.352	2.149	17.905	64.352
4	.846	7.052	71.404						
5	.756	6.301	77.705						

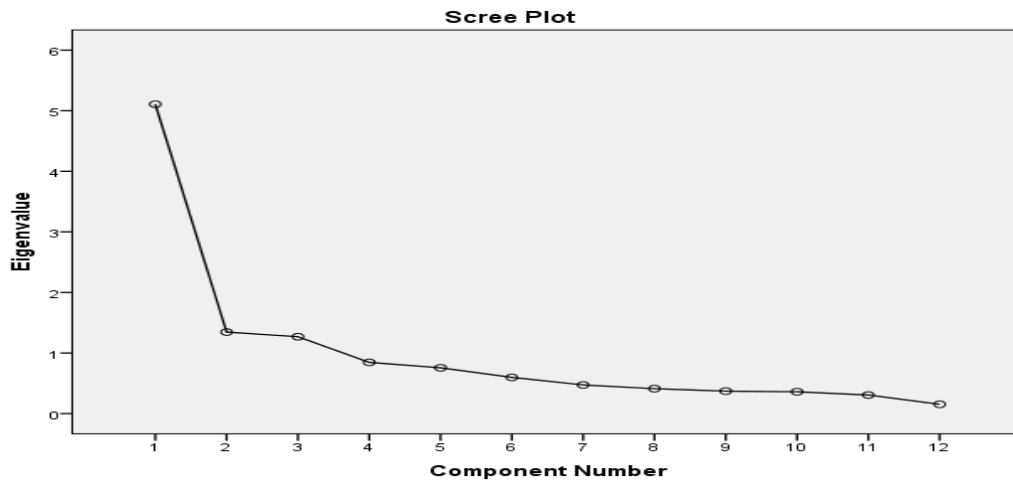


Fig. 4. Scree plot for teachers with more than 7 years teaching experience

#### 4. DISCUSSION OF FINDINGS

The main objective of the study was to establish whether the TSES factor structure generalizes across pre-service and in-service teachers. Principal component analysis with Varimax rotation indicated a one factor solution for the in-service teachers. This result is consistent with previous finding from studies done in the USA [20] and Botswana [21]. Taking into consideration the fact that the self-efficacy construct is defined by three separate factors (i.e., classroom management, instructional activities, and learner engagement), a unidimensional solution for in-service teachers is a cause for concern. Unidimensionality actually implies that the pre-service teachers have a rather simplistic view of classroom process. It is of critical importance that teachers develop competencies in these three areas for them to be seen to be effective and efficient in the delivery of instructions. Competency in classroom management enables the teacher to handle all students in order to create a conducive learning environment. Any weakness or deficiency in classroom management may undermine the teacher's ability to function effectively in the classroom.

The situation for in-service teachers is not as clear cut like that presented for pre-service teachers. The results have indicated that the self-efficacy beliefs for practicing teachers is influenced by the number of years spent in the field. The factor structure for teachers with less than seven years in the field is characterized by one clearly dominant factor. There is some

evidence supporting the emergence of a second factor but the meaningfulness of the factor is not backed by empirical evidence. However, an argument can be made that the teachers are slowly transitioning from a unidimensional mode to multidimensional frame of reference. On the other hand, both the Kaiser criterion and the scree plot indicated a three factor solution to be the most parsimonious and theoretically meaningful based on the factor loading patterns and item clustering. After seven years of teaching, this group of teachers have come to realize the limitation of the one-size fits all approach to the learning and teaching process. The appearance of three distinct factors for teachers with more than seven years of teaching shows that these teachers are able to execute a learning and teaching plan than has all the three elements of TSES. The teachers have developed self-efficacy competencies in classroom management, instructional planning, and learner engagement.

One point that has emerged from this study is that teachers self-efficacy beliefs evolve rather slowly from a unidimensional outlook to a multifaceted three factor construct. Unidimensionality implies lack of knowledge or distinct competencies in classroom management, instructional planning and learner engagement. Teachers have to develop plans that clearly show how they are going to deal with each of these three areas during the lesson. Progression from a unidimensional mode of thinking to a multidimensional perspective is an indication of the ability to handle these three elements as separate entities.



Findings from the current study shows that teachers spend up to seven years before they begin to appreciate the complexities of the learning and teaching process. This state of affairs is undesirable as it means that teachers start practicing without the knowledge and skills necessary for them to be effective and efficient in the field. The seven year that teachers take to become fully productive appears to be too long by all intents and purposes. Modalities and some targeted intervention strategies should be devised to ensure that teachers are ready to "hit the ground running" once they start practicing.

## 5. CONCLUSION

The factor analytic study has produced two interesting findings. Firstly, the emergence of a unidimensional model for pre-service teachers and a multidimensional factor structure for teachers with more than seven years teaching experience confirms findings from previous studies. Secondly, the data has revealed that practicing teachers are not a homogeneous sample. Practicing teachers with up to seven years teaching experience exhibit self-efficacy beliefs that are not so different from those held by pre-service counterparts. Therefore, targeted intervention strategies should be formulated for these two groups. The teacher training programme should be reviewed so as to incorporate content that will assist pre-service teachers to improve their self-efficacy competencies in the three identified areas. An almost parallel programme should be put in place for practicing teachers presenting low self-efficacy competencies. The main objective of the parallel programme would be to in-service the teachers to help them develop strong dispositions in classroom management, instructional activities, and learners engagement. The eventual success of the programme would require full participation of the school heads and school inspectors. These are the government officials who interact with the teachers on daily basis. Therefore, school heads and school inspectors have to be given the tools that will enable them to assist teachers at the classroom level.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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