EXAMINING MEASUREMENT PROPERTIES OF MATHEMATICS SELF-EFFICACY SCALE AMONG SENIOR SECONDARY SCHOOL STUDENTS IN OYO STATE, NIGERIA

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Abstract
The purpose of this study was to examine the measurement properties of Mathematics Self-Efficacy Scale (MSES) among senior secondary school students in Oyo State, Nigeria. The instrument is meant for assessing mathematics self-efficacy of senior secondary school student as the target population and 515 students were used for the study. The distribution of the participants are as followed 53.2% boys and 46.8% girls and the age ranged is between 14 to 17 years (M = 15.3 years, SD=1.13) that are attending the senior secondary school classes. These students were from 33 public senior secondary schools in the thirty local government area of Oyo state. 16 students were selected from twenty local government area and 15 students from the rest thirteen local government areas. Three research questions were raised to guide the study. The results of the MSES analysis reveal that the mathematics self-efficacy scale among senior secondary school students in Oyo state comprises of four dimensions namely: (a) Ability to remember and to use formulae correctly (b) Possession of mathematical ability (c) Mathematics area/topics of focus and (d) Student's mathematics resilient. The researcher further tested whether the MSES is tenable using confirmatory factor analysis. The result of Confirmatory Factor Analysis provides a good fit of the data within the hypothesized four-factor model, implying that the MSES can be subsumed into four domains. Discriminant and Convergence validities were moderate ranging from .33 to .67. Alpha coefficients for four MSES subscales ranged from .61 to .86, and .89 for the whole scale. The study recommends the MSES for other researchers to assess mathematics self-efficacy among senior secondary school students in the schools in their locality in Nigeria and elsewhere.
Keywords: Examining, Measurement, Properties, Mathematics, Self-Efficacy

Introduction

Four decades have now passed since Bandura (1977) first introduced the construct of self-efficacy with the seminal publication of "Self-efficacy: Toward a Unifying Theory of Behavioural Change." A decade later, Bandura (1986) situated the construct within a social cognitive theory of human behaviour that diverged from the prevalent cognitivism of the day and embedded cognitive development within a socio-structural network of influences. More recently, Bandura (1997) published Self-efficacy: The Exercise of Control, in which he further situated self-efficacy within a theory of personal and collective agency that operates in concert with other socio-cognitive factors in regulating human well-being and attainment. In that volume, Bandura also addressed the major facets of agency -- the nature and structure of self-efficacy beliefs, their origins and effects, the processes through which such self-beliefs operate, and the modes by which they can be created and strengthened. In addition, Bandura reviewed a vast body of research on each of these aspects of agency in diverse applications of the theory.

Self-efficacy beliefs have also received increasing attention in educational research, primarily in studies of academic motivation and of self-regulation. In this arena, self-efficacy researchers have focused on three areas. Researchers in the first area have explored the link between efficacy beliefs and college major and career choices, particularly in science and mathematics (Lent & Hackett, 1987). This line of inquiry has important implications for counseling and vocational psychology theory and practice, given that findings have provided insights into the career development of young men and women and can be used to develop career intervention strategies. Findings from the second area suggest that the efficacy beliefs of teachers are related to their instructional practices and to various student outcomes (Ashton & Webb, 1986). In the third area, researchers have reported that students' self-efficacy beliefs are correlated with

other motivation constructs and with students' academic performances and achievements. Constructs in these studies have included attributions, goal setting; modeling, problem-solving, test and domain-specific anxiety, reward contingencies, self-regulation, social comparisons, strategy training, other self-beliefs, and expectancy constructs, and varied academic performances across domains.

Self-efficacy's broad application across various domains of behaviour has accounted for its popularity in contemporary motivation research (Kabiri & Kiamanesh, 2004; Liu & Koirala, 2009). Now that two decades have passed, the time seems propitious to assess the direction that this bourgeoning line of inquiry has taken in academic contexts. To that end, the purpose of this study is to acquaint the reader with the defining characteristics of self-efficacy beliefs, outline some problems that have plagued research in this area, examine current directions in self-efficacy research, and suggest strategies to guide future directions. To set the foundation for this exploration, a brief overview of the role of self-belief in Bandura's social cognitive theory will first be offered. This will be followed by a more in-depth examination of the sources, effects, and defining characteristics of self-efficacy beliefs, as well as of some problems that affect research.

How people interpret the results of their own performance attainments informs and alters their environments and their self-beliefs which, in turn, inform and alter subsequent performance. This is the foundation of Bandura's (1986) conception of reciprocal determinism, the view that (a) personal factors in the form of cognition, affect, and biological events, (b) behaviour, and (c) environmental influences create interactions that result in a triadic reciprocation. In general, Bandura provided a view of human behaviour in which the beliefs that people have about themselves are key elements in the exercise of control and personal agency and in which individuals are viewed both as products and as producers of their own environments and of their social systems.

Bandura (1986) wrote that, through the process of self-reflection, individuals are able to evaluate their experiences and thought processes (Dewey, 1933). According to this view, what people know, the skills they possess, or what they have previously accomplished are not always good predictors of subsequent attainments because the beliefs they hold about their capabilities powerfully influence the ways in which they will behave. Consequently, how people behave is both mediated by their beliefs about their capabilities and can often be better predicted by these beliefs than by the results of their previous performances. This does not mean that people can accomplish tasks beyond their capabilities simply by believing that they can, for competent functioning requires harmony between self-beliefs on the one hand and possessed skills and knowledge on the other. Rather, it means that self-perceptions of capability help determine what individuals do with the knowledge and skills they have. More important, self-efficacy beliefs are critical determinants of how well knowledge and skill are acquired in the first place.

The process of creating and using these self-beliefs is an intuitive one: individuals engage in behaviour, interpret the results of their actions, use these interpretations to create and develop beliefs about their capability to engage in subsequent behaviours in similar domains, and behave in concert with the beliefs created. In school, for example, the beliefs that students develop about their academic capabilities help determine what they do with the knowledge and skills they have learned. Consequently, their academic performances are in part the result of what they come to believe that they have accomplished and can accomplish. This helps explain why students' academic performances may differ markedly when they have a similar ability. Researchers have suggested that these self-beliefs may play a mediational role in relation to cognitive engagement and that enhancing them might lead to increased use of cognitive strategies that, in turn, lead to improve performance (Pintrich, Wolters & Baxter, 2000). This view of self-belief as a mediating construct in human behaviour is consistent with those of numerous scholars and theorists who have argued that the potent evaluative nature of beliefs makes them a filter through which new phenomena are interpreted and subsequent behaviour mediated (Adeyemo, 2009; Dougherty & Johnson, 2007; Marsh, Trautivein, Ludtke, Koller & Baumert, 2005).

The self-beliefs that individuals use to exercise a measure of control over their environments include self-efficacy beliefs -- "beliefs in one's capability to organize and execute the courses of action required managing prospective situations" (Bandura, 1997). Because self-efficacy beliefs are concerned with individuals' perceived capabilities to produce results and to attain designated types of performance, they differ from related conceptions of personal competence that forms the core constructs of other theories. Self-efficacy judgments are both more task- and situation-specific, contextual if you will, and individuals make use of these judgments in reference to some type of goal. To better understand the nature of self-efficacy beliefs it may be useful to explain how they are acquired, how they influence motivational and self-regulatory process, and how they differ from similar or related conceptions of self-belief.

The case for the contextual and mediational role of self-efficacy in human behaviour can be made by exploring the four sources from which these beliefs are developed. The most influential source of these beliefs is the interpreted result of one's purposive performance or mastery experience. Simply put, individuals gauge the effects of their actions, and their interpretations of these effects help create their efficacy beliefs. Outcomes interpreted as successful raise self-efficacy; those interpreted as failures lower it. Bandura's (1986) emphasis that one's mastery experiences are the most influential source of self-efficacy information has important implications for the self-enhancement model of academic achievement, which contends that to increase student achievement in school, educational efforts should focus on altering students' beliefs of their self-worth or competence. This is usually accomplished through programs that emphasize enhancing self-beliefs through verbal persuasion methods. Social cognitive theorists shift that emphasis and focus on a joint effort to raise competence and confidence primarily through successful experience with the performance at hand, through authentic mastery experiences. They argue that interventions should be designed accordingly.

The second source of efficacy information is the vicarious experience of the effects produced by the actions of others. This source of information is weaker than the interpreted results of mastery experiences, but, when people are uncertain about their own abilities or have limited prior experience, they become more sensitive to it. As Schunk (1987) has demonstrated, the effects of models are particularly relevant in this context. A significant model in one's life can help instill self-beliefs that will influence the course and direction that life will take. Part of one's vicarious experience also involves the social comparisons made with other individuals. These comparisons, along with peer modeling, can be powerful influences on developing self-perceptions of competence (Schunk, 1983). Interaction effects can complicate the evaluation of the relative power of different modes of influence. For example, a model's failure has a more negative effect on the self-efficacy of observers when observers judge themselves as having comparable ability to the model. If, on the other hand, observers judge their capability as superior to the model's capability, the failure of the model does not have a negative effect (Kabiri & Kiamanesh, 2004; Liu & Koirala, 2009).

Individuals also create and develop self-efficacy beliefs as a result of the verbal persuasions they receive from others. These persuasions involve exposure to the verbal judgments that others provide and are a weaker source of efficacy information than mastery or vicarious experiences, but persuaders can play an important part in the development of an individual's self-beliefs (Kabiri & Kiamanesh, 2004; Liu & Koirala, 2009). Effective persuasions should not be confused with knee-jerk praise or empty inspirational homilies (Bandura, 1997). This is consistent with Erikson's (1980) caution that a weak ego is not strengthened by being persistently bolstered and that "children cannot be fooled by empty praise and condescending encouragement". Rather, "a strong ego, secured in its identity by a strong society, does not need, and in fact, is immune to any attempt at artificial inflation". Persuaders must cultivate people's beliefs in their capabilities while at the same time ensuring that the envisioned success is attainable. And, just as positive persuasions may work to encourage and empower, negative persuasions can work to

defeat and weaken self-beliefs. In fact, it is usually easier to weaken self-efficacy beliefs through negative appraisals than to strengthen such beliefs through positive encouragement (Bandura, 1986).

Strong self-efficacy beliefs enhance human accomplishment and personal well-being in many ways. People with a strong sense of personal competence in a domain approach difficult tasks in that domain as challenges to be mastered rather than as dangers to be avoided, have greater intrinsic interest in activities, set challenging goals and maintain a strong commitment to them, heighten their efforts in the face of failure, more easily recover their confidence after failures or setbacks, and attribute failure to insufficient effort or deficient knowledge and skills which they believe they are capable of acquiring. High self-efficacy helps create feelings of serenity in approaching difficult tasks and activities. Conversely, people with low self-efficacy may believe that things are tougher than they really are a belief that fosters stress, depression, and a narrow vision of how best to solve a problem. As a result of these influences, self-efficacy beliefs are strong determinants and predictors of the level of accomplishment that individuals finally attain. For these reasons, Bandura (1986, 1997) has made the strong claim that beliefs of personal efficacy constitute the key factor of human agency.

Some researchers have assessed judgments of self-efficacy in terms of particularized self-perceptions of competence highly consistent with the criteria task being assessed. This assessment requires that, if the criteria task involves solving specific mathematics problems, the efficacy assessment asks students to provide judgments of confidence to solve similar problems; if the task involves reading comprehension, students are asked to provide judgments of their perceived capability to correctly answer various questions that tap comprehension of the main ideas in a passage; if the task involves writing an essay, students are asked to provide judgments that they possess the various composition, grammar, usage, and mechanical skills on which their writing performance is assessed (May & Glynn, 2008; Kabiri & Kiamanesh, 2004).

The mathematics judgments assessed by the different subscales of the MSES are substantively different and tap differing math-related beliefs. Although all are math-related, their predictive value should depend on the nature of the criteria tasks with which they are compared. Consequently, students' judgments to solve math problems should be more strongly predictive of their capability to solve those problems than should their confidence to perform other math-related tasks or succeed in math-related courses. Similarly, their judgments to succeed in math-related courses should be more strongly predictive of their choice to enroll in such courses than should their confidence to solve specific problems or perform math-related tasks. Pajares and Miller (1995) compared these judgments of capability with two outcome measures: the ability to solve the problems on which self-efficacy was assessed and math-relatedness of academic majors. Results confirmed that Bandura's (1986) cautions regarding the specificity of self-efficacy and performance assessment are well-founded. Students' confidence to solve mathematics problems was a more powerful predictor of their ability to solve those problems than was their confidence to perform math-related tasks or their confidence to earn A's or B's in math-related courses. Similarly, their confidence to succeed in such courses was more predictive of their choice of majors that required them to take many of the math-related courses on which they expressed that confidence.

Self-efficacy beliefs are a main factor in someone's decision-making process, e.g. the choice of academic courses or career decisions (May & Glynn, 2008). Especially low self-efficacy beliefs lead to negative decisions in the related domain. Successful learning scenarios – at school or at university – should increase learners' self-efficacy expectations as well as their skills and knowledge. A main source of self-efficacy expectations is one's own successful performance. If a student completes a task autonomously with more or less feedback, s/he develops positive expectations to handle new and unknown situations or problems. However, the effect could be weaker due to the non-existing own performance if learners only 'consume' information about how to solve the task.

Statement of the Problem

The instrument was constructed base on the fact that there is no known any local instrument on mathematics self-efficacy scale to the best of the knowledge of the researcher. Also, the research thought there ought to be a measure that can be used to determine the mathematical ability of individual that are fits or intends to read mathematics, science and allied science courses at higher level of education. Also, to avoid cultural bias in using foreign test to measure the mathematics confidence of the learners.

Purpose of the Study

The main purpose of this study is to examine the properties of mathematics self-efficacy scale among senior secondary school students in Oyo state, Nigeria. Therefore, the specific purpose of this study is to measure the indicative factors of MSE, convergence and divergence validity and reliability of the instrument.

Research Questions

1. What are the indicative factors of MSES?
2. What are the discriminant and convergent validity of the MSES?
3. What are the reliability of the MSES (Internal consistency)?

Methodology

The population of interest here are senior secondary school students in Oyo state, Nigeria. The researcher chosen 515 senior secondary school students, out of which 53.2% are boys and 46.8% are girls and their age ranged is between14 to 17 years (M = 15.3 years, SD=1.13) they are senior secondary school class. These students were from 33 public senior secondary schools in the thirty local government area of Oyo state. There are thirty-three local government area in Oyo state and the researcher make sure that each local Government has participants. Therefore, simple random sampling were used to select 16 students from twenty local government area and 15 students from the rest thirteen local government areas based on the densely populated school in each local government. The reason behind this selection of participants from the thirty-three local government area of the state is to have good representatives of the participants across the state.

Instruments

Three different instruments were used in this study which are MSES, Self-Regulation Questionnaire (SRQ) and the third one is Diana Mathematics Self-Efficacy scale (DMSES). The instruments for data collection were MSES which is to be validated by the researchers. Mathematics Self-Efficacy Scale (MSES) - It is a 47 items evaluation instrument developed to assess mathematics self-efficacy of senior secondary school students through self-report. The items are answered on a 7-point Likert scale with the following scale points: 1 = I am totally unable to do this, 2= I am unable to do this, 3= I am possibly unable to do this, 4= I am possibly able to do this, 5= I am basically and in principle able to do this, 6= I am able to do this and 7 = I am able to do this well. The items were generated from mathematics syllabus prepared for secondary school students and based on the work carried out by Fehintola (2011). Diana Mathematics Self-efficacy Scale (DMSES), is a 14 items instrument rated on 4-Likert points type ranging from 4 = strongly agree (SA) to 1 = strongly disagree (SD). The instrument was developed by Diana (2009) the instrument has an original reliability coefficient of 0.76. SRQ-the Self-Regulation Questionnaire (SRQ) was adopted from Brown, Miller & Lawendowski, (1999). 20 items of the questionnaire were adopted to assess self-regulatory processes through self-report. The items are answered on a 5-point Likert scale with the following scale points: 1 = strongly disagree, 2= Disagree, 3= Uncertain or Unsure, 4= Agree, 5= Strongly Agree. The authors reported Test-retest reliability for the total SRQ score to be very high (r = .94) and DMSES.

The researchers went through the secondary school mathematics curriculum is used in secondary schools through the educational system in Nigeria and from there the researcher is able to extract 47 items that

became the scale MSES. The researcher administered the three instruments simultaneously for the purpose of validating the new instrument (MSES). The filled questionnaires were used to establish the validity of the instrument and the factor analysis of the instrument. The data collected were analyzed based on each research question. Research question one was answered using factor analysis while Pearson product-moment correlation was used to answer research question two and the Cronbach reliability coefficient of concordance was used to answer research question three.

Results

Research Question 1: What are the indicative factors of MSES?

Table 1: Pattern Matrix of Structure and Communalities of the Four MSES Factors

Items	Factor 1	Factor 2	Factor 3	Factor 4	h^2
1	0.908				0.774
2	0.837				0.718
13	0.830				0.811
14	0.645				0.741
23	0.573				0.715
44	0.558				0.633
3		0.975			0.787
4		0.964			0.860
6		0.905			0.903
9		0.960			0.502
10		0.951			0.873
11		0.903			0.840
13		0.906			0.774
15		0.903			0.812
20		0.881			0.812
24		0.834			0.502
25		0.870			0.838
26		0.837			0.713
28		0.830			0.811
29		0.658			0.754
32		0.645			0.741
40		0.636			0.660
41		0.573			0.715
45		0.556			0.633
5			0.960		0.873
7			0.951		0.840
8			0.903		0.812
21			0.870		0.838
22			0.658		0.754
33			0.636		0.660
37			0.448		0.412
16				0.875	0.788
17				0.964	0.860
18				0.905	0.905
19				0.881	0.826
27				0.834	0.502
30				0.808	0.624
31				0.643	0.684
34				0.658	0.754
35				0.636	0.660
36				0.448	0.412
38				0.645	0.741
39				0.573	0.715

42	0.558	0.633
43	0.416	0.613
46	0.448	0.412
47	0.356	0.664

Note: N= 515, h^2 = item communalities. 4 factors extracted.

The 4 Factors
[A] Ability to remember and to use formulae correctly
[P] Possession of mathematical ability
[N] Mathematics area/topics of focus
[S] Student's mathematics resilient
It is important to note that:
(i) FL (factor loading) range used in selection is 0.35 and above (Meredith, 1969);
(ii) Items without any FL up to 0.35 are considered factorial impure and not selected; Table1 shows the summary of factor analysis. A total of 47 items were selected for having FL of 0.35 and above.

Research Question 2: What are the discriminant and convergent validity of the MSES?

Table 2: Inter-correlations of Scores for the Mathematics Self-Efficacy Scale, Self-Regulation Questionnaire and Diana Mathematics Self-Efficacy Scale

Factors	1	2	3	4	5	6	7
1.A	1.00(.94)						
2.B	.27**	1.00	(.90)				
3.C	.47**	.23**	1.00	(.81)			
4.D	.25**	.32**	.30**	1.00	(.74)		
5.E	.28**	.25**	.20**	.24**	1.00	(.71)	
6.F	.17**	.38**	.25**	.21**	.13	1.00	(.68)
7.G	.52**	.35**	.19**	.57**	.15	.81**	1.00

[A] Ability to remember and to use formulae correctly
[B] Possession of mathematical ability
[C] Mathematics area/topics of focus
[D] Student's mathematics resilient
[E] (Self-Regulation Scale)
[F] Diana Mathematics Self-efficacy Scale (DMSES)
[G] MSES

Discriminant validity is a piece of evidence that one concept is different from other closely related concepts. To establish the discriminant validity, the researcher made use of 'Self-Regulation Scale' scores with MSES. The validity coefficient between these instruments is 0.16.The results showed that there is no significant relationship between the two scales. Convergent validity is evidence that the same concept measured in different ways yielded close/similar results. In this study, convergent validity was assessed by studying the relationship between MSES and ACETPAF. The convergent validity coefficient between MSES and DMSES is $r = 0.81$ $p < .05$. This was evidence that the convergent validity between MSES and DMSES is significant.

Research Question 3: What will be the reliability of the MSES (Internal consistency)?

The items derived from the factor analysis were tested for their reliability using the item-total correlation to analyze them. Items for each subscale were analyzed separately. The overall internal consistency reliability coefficient (Cronbach alpha) for the TPARS was .79. The internal consistencies obtained for each of the four factors as shown in Table 2 in parentheses.

Factor A – (Ability to remember and to use formulae correctly) $\alpha = 0.94$
Factor B – (Possession of mathematical ability) $\alpha = 0.90$
Factor C – (Mathematics area/topics of focus) $\alpha = 0.81$
Factor D – (Student's mathematics resilient) $\alpha = 0.74$

Discussion

As shown in Table1, the factorial validity (FLs) of the 47 items of MSES ranges from 0.35 and above. This is an indication that the 47 items are valid to evaluate mathematics self-efficacy of senior secondary school students in institutions in Nigeria. This is in line with Meredith (1969) who recommended a FL of 0.35 and above as minimum for accepting any item as valid. This, therefore, implies that the items of MSES are adequate and representative of the various constraints of mathematics self-efficacy of senior secondary school student's mathematics ability. A confirmatory factor analysis indicated that a four-component structure best represents the MSES of the students. The four subscales of MSES demonstrated adequate internal consistency reliabilities of the MSES. The following domains were represented by the four-component structure: Ability to remember and to use formulae correctly (b) Possession of mathematical ability (c) Mathematics area/topics of focus and (d) Student's mathematics resilient.

The results of this study have shown that MSES has high-reliability coefficients, and therefore, reliable and valid and can be used to measure mathematics self-efficacy. As shown in Table2, the overall reliability coefficient of all the factors of MSES is 0.79. This implies that researchers can use MSES in measuring mathematics self-efficacy of mathematics learners without differences in their scores. In other words, the use of this instrument will help researchers to measure student's mathematics self-efficacy on the skills acquired and the level of acquisition thereby finding out the extent of students mathematics confidence. Therefore, the reliability coefficient of this instrument is considered adequate enough for use by researchers to effectively measure student's mathematics self-efficacy.

Concerning the divergent validity of MSES subscales, there is no significant correlation between measures of SRQ and MSES subscales provide the evidence for the divergent validity of MSES. This is because students having high MSES are not likely to have high self-regulation. Therefore, the relationship between MSES and SRQ scores indicated that there is no significant relationship between the two scales. And this always the case when two instruments are measuring the same construct the correlation between the two will not be significant.

Conclusion

The researcher concludes that mathematics self-efficacy can be measured by the constructed and validated (MSES) instrument to provide an appropriate measure of the target students' disposition towards mathematics (ability to remember, write and to use formulae correctly, possession of mathematical ability, and mathematics area/topics of focus and student's mathematics resilient).

Recommendations

Based on the construct validity, the divergent, convergent validity and the reliability coefficients obtained in this study, the researcher recommends that:

1. Researchers in tertiary institutions and elsewhere can make use of this MSES to assess mathematics self-efficacy of their participants in any given study that has to do with mathematics self-efficacy.
2. MSES can also be used to assess and predict students' performance in mathematics.
3. MSES can also be used in examining therapy outcomes for students' mathematics learning performance.
4. MSES can be used to diagnose students' mathematical ability.

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