Self-Efficacy Beliefs Instrument: Use of History of Mathematics in Mathematics Teaching

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Abstract

This study is related to the use of the tool of self-efficacy beliefs in teaching mathematics through using history of mathematics, based on Self-efficacy Theory of Bandura (1977). The instrument is adapted from Enoch, Smith and Huinker's (2000) instrument which contains 21 statements grouped into two dimensions of self-efficacy beliefs: personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE). Exploratory factor analysis was employed to maintain construct validity; and reliability was maintained by Cronbach alpha ($\alpha = .829$, $N = 305$) to assess internal consistency of the items. Pre-service mathematics teachers' self-efficacy beliefs can be increased through the use of this tool.

Keywords: -Efficacy, beliefs, instrument, mathematics, Nepal

Introduction

This study aims to establish the relation between the use of self-efficacy beliefs tool and performance of mathematics teachers. Moreover, the instrument is used as a valid and reliable tool for investigating prospective mathematics teachers' (PMTs) self-efficacy beliefs about the use of history of mathematics (HM) in mathematics teaching. The use of HM in mathematics teaching is considered as an alternative instruction that utilizes primary and secondary sources of HM through old mathematics problems, original mathematics texts, biographies of premier mathematicians, etc. (Tzanakis & Arcavi, 2000). There have been substantial studies in the field of self-efficacy beliefs however; there is a scarce of empirical research related to self-efficacy beliefs regarding the use of HM. Further, Self-Efficacy Beliefs Instrument (SEBI) employing Self-Efficacy (SE) Theory (Bandura, 1977) for the assessment of the use of HM does not exist so far.

The instrument utilizes the SE Theory (Bandura, 1977) as theoretical framework to measure self-efficacy beliefs about the use of HM in mathematics teaching. According to Bandura (1995), "self-efficacy is the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (p. 2). The basic principle of SE Theory (Bandura, 1977) is that every individuals are more likely to get engaged in the activities which can arouse higher level of self-efficacy and less likely to engage in themselves which have lower level of self-efficacy potential (Van der Bijl & Shortridge-Baggett, 2002). Bandura (1977) argues that a person's future behavior can be predicated by the degree of her/his beliefs that the behavior is efficaciously executed. Within the context of Bandura's SE (1977) Theory, teacher efficacy beliefs are viewed as a subset of the general construct of efficacy beliefs, and are related to the extent to which teachers view themselves as capable of affecting student learning.

The SE Theory regards self-efficacy as the driving force of behavior change. In teaching profession, self-efficacy is meant for the teacher's confidence in their teaching behavior; and this trait can flourish in the classroom (Ross, McKeiver & Hogaboam-Gray, 1994). As found by Czerniak and Schriver (1994) teachers with higher level of efficacy have the tendency of using inquiry based teaching strategies which are more learner-centered but the teacher's having lower level of efficacy mostly follow teacher centered approach. Thus, we can understand that self-efficacy belief is related to the level of confidence in performing some behavior. In this scenario, we can conclude the quality of belief in the individual that directs her/him towards the desired goal.

Bandura's (1977) self-efficacy is based on two dimensions of beliefs: efficacy expectations and outcome expectations. Bandura defined efficacy expectations as an individual's belief that s/he can execute the necessary actions to complete a task. Similarly, outcome expectations were defined as her/his beliefs that performance of a task will lead to certain outcomes. In this regard, Smith, Huinker and Enochs (2000) opine that Bandura's efficacy theory depends on two strands: personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE) in the context of mathematics teaching. PMTE has been defined as a belief in one's ability to teach mathematics effectively; and MTOE as the belief that effective mathematics teaching will have a positive effect on student's learning (Ibid). In this study, Self-efficacy refers to PMTs' perceptions of their capability to carry out teaching behavior through the use of HM.

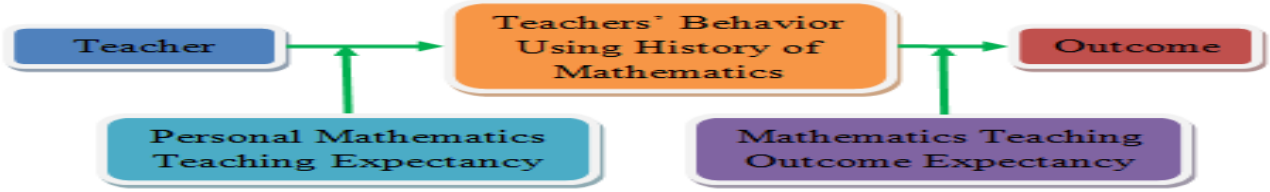

Figure 1. Schematic presentation of Bandura's Self-Efficacy Model, 1977

Methods

Methods of this study consisted of two parts: choosing the sample and using SEBI as a tool of data collection for measuring the self-efficacy beliefs about the use of HM in mathematics teaching.

Sample

This study was conducted in a sample of 305 students studying Master of Education with mathematics specialization, called PMTs. The participant campuses were selected by means of random sampling method; and the participants were selected following criterion purposive sampling method. Participants had at least one year of teaching experience, and qualified from HM course. Of the participants, 183 (60%) were male and 122 (40%) were female. The range of teaching experience for the sample was flexible and lied between 1 and 10 years. The average age of the participants was 24 years.

Instrument

The instrument of this study for measuring self-efficacy beliefs was SEBI. SEBI was adapted with the modification of previous Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) survey study of Enochs, Smith and Huinker (2000). The MTEBI has been established as the most valid and reliable instrument and is frequently used in measuring pre-service elementary mathematics teachers' self-efficacy beliefs on mathematics teaching. The items were modified regarding the context of using HM in teaching mathematics.

A five-point Likert scale of SEBI was constructed on the basis of two sub-scales of self-efficacy beliefs: PMTE and MTOE. The PMTE subscale consisted of 13 items that relate to PMTs' beliefs regarding their capability to teach mathematics effectively; and the MTOE subscale includes 8 items that relate to their beliefs that effective teaching can get better students' achievement. The PMTE items 2, 3, 5, 6, 8, 11, 15, 16, 17, 18, 19, 20, 21 measured the self-efficacy and MTOE items 1, 4, 7, 9, 10, 12, 13, 14 measured outcome expectancy. Seven items of PMTE were written in positive orientation and 6 were written negatively; and MTOE included 6 positively worded and 2 negatively worded items. The PMTE items were stated in the first person and written in future tense; but the MTOE items were stated in third person and written in present tense. The items of SEBI were distinguished by initials of personal efficacy (P) and outcome expectancy (O) (Appendix).The sample items related to PMTE and MTOE were:

PMTE Item: P5. I know how to teach mathematical concepts effectively through the use of historical mathematical contents as developed in the history of mathematics.

MTOE Item: O13. Student's achievement in mathematics is directly related to their teacher's effectiveness of teaching mathematics through HM

Analysis

In order to analyze the data of the SEBI, exploratory factor analysis (EFA) was employed to identify the factors of SEBI, Pearson correlation coefficient for analyzing the relation between the factors PMTE and MTOE; and Cronbach alpha was utilized for analyzing the internal consistency between the items. Validity and reliability of the instrument were established through the following procedures.

Validity and reliability

To maintain validity and reliability of the SEBI, a pilot study was conducted to see how far the adapted SEBI scale would be reliable in using HM. So, the tool was piloted in a small group with subjects of the same profile (Brown & Dowling, 1998). The pilot study was performed with 31 PMTs.

To ensure content validity, the researcher consulted with three research experts for necessary corrections in the instrument. Since adequate sample size generates high validity, a sample of 305 participants was considered suitable for maintaining validity. The researcher conducted an EFA of 305 PMTs' five-point Likert data to ensure construct validity of the SEBI and found two factors: PMTE and MTOE. Factor analysis served the purpose of sorting the items which were interrelated in a test into sub-dimensions (George & Mallery, 2001). The correlation coefficient between PMTE and MTOE was located .607. A correlation coefficient of .60 or above will indicate a significant positive relationship (Creswell, 2005).

Principal components analysis with oblique rotation was performed on SEBI to determine whether the sub-scale items created were separate and distinct factors. Using SEBI, as the researcher consistently found two distinct factors, a forced two-factor solution was chosen. The values of Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy obtained in SEBI was high (.767) and the results of Barlett's test were significant ($p < 0.000$), which indicated that the data were appropriate for analysis. (Approx. Chi-Square was 3313.591 with degree of freedom 210). The KMO value should be at least .6 for checking sample adequacy (Pallent, 2007).

The first factor consisting of 13 items explained 19.810 % of variance with eigenvalue 6.160; and the second consisting of 8 items explained 14.485% with eigenvalue 4.242 (Table 1). Table 1 shows that the first factor: PMTE, consisted the item numbers 17, 15, 5, 19, 8, 11, 3, 16, 6, 18, 2, 20 and 21; and the second factor: MTOE, consisted the item numbers 13, 7, 9, 14, 12, 4, 10 and 1 according to their factor loadings. When the items of first and the second factor were combined, all 21 items yielded the total explanation of 34.295%. All the items had at least .3 factor loadings that maintained moderate category.

Table 1 *Factor Loadings and Cumulative Percentage of Self-Efficacy Beliefs Instrument*

Item No.	Factors Loadings	
	Component 1(PMTE)	Component 2 (MTOE)
Item No. 17	.814	
Item No. 15	.625	
Item No. 5	.613	
Item No. 19	.530	
Item No. 8	.518	
Item No. 11	.502	
Item No. 3	.479	
Item No. 16	.461	
Item No. 6	.431	
Item No. 18	.345	
Item No. 2	.322	
Item No. 20	.313	
Item No. 21	.307	
Item No. 13		.740
Item No. 7		.665
Item No. 9		.661
Item No. 14		.533
Item No. 12		.502
Item No. 4		.426
Item No. 10		.310
Item No. 1		.305
Eigen Value	6.160	4.242
Percentage of variance	19.810	19.810
Cumulative variance	14.485	34.295
Cronbach Coefficient alpha	.798	.860

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Reliability was maintained through appropriate literature review, receiving feedback from mathematics educators and avoiding duplication of sample. Similarly, internal consistency of the scales was measured through Cronbach coefficient alpha to maintain reliability of the SEBI. As an indicator of reliability, Cronbach coefficient alpha was detected as .787 (N = 31) in the pilot study. It indicated that the 21 items had high internal consistency. After conducting the main study, the reliability of SEBI was computed once more. The Cronbach coefficient alpha of full study was detected as .829 (N = 305). Similarly, Cronbach coefficient alpha of sub-scale PMTE and MTOE were computed separately, which were found to be .798 and .860 (N = 305) respectively (Table 1).

Conclusion

SEBI can be used as a valid and reliable instrument to measure pre-service teachers' self-efficacy beliefs about the use of HM in mathematics teaching. This was evidenced by exploratory factor analysis that was conducted to ensure construct validity of SEBI with two factors: PMTE and MTOE, having Cronbach coefficients alpha.798 and .860 (N = 305) respectively. The correlation coefficient between PMTE and MTOE was located .607. However, SEBI scale may need to be modified for validity and reliability in additional contexts because validity and reliability is ongoing and never-ending process. Based on this study, it is expected that this reliable and validated SEBI could be used to measure the pre-service teachers' self-efficacy beliefs regarding the context of using HM. Its utility across subject domains is important, so testing of this SEBI scale in other subject matter areas will provide further credibility to its importance as a tool for determining professional development of prospective teachers. Hence, it is recommended that further studies can be conducted to confirm the reliability and validity of this instrument across subjects.

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Appendix: Self-Efficacy Beliefs Instrument

Please, study each statement carefully and indicate your opinion by putting tick mark (√) to the right on any one of the five ratings for each statement.

SD: Strongly Disagree, D: Disagree, N: Neutral, A: Agree, SA: Strongly Agree

Item No.	Statements	SD (1)	D (2)	N (3)	A (4)	SA (5)
O1.	When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort through some relevant story and problems from the HM.	SD	D	N	A	SA
P2.	I will continually find better ways to teach mathematics by using historical contents of mathematics.	SD	D	N	A	SA
P3.	Even if I try very hard, I do not teach mathematics easily using historical contents of mathematics in the class.	SD	D	N	A	SA
O4.	When the achievement of students in mathematics improves, it is due to integration of relevant contents from the HM.	SD	D	N	A	SA
P5.	I know how to teach mathematical concepts effectively through the use of the sequence of contents as developed in the HM.	SD	D	N	A	SA
P6.	While using historical mathematical texts, I will not be very effective in monitoring mathematical activities.	SD	D	N	A	SA
O7.	If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching through biographies of premier mathematicians.	SD	D	N	A	SA
P8.	I will generally teach mathematics ineffectively by using the HM as contents and pedagogies.	SD	D	N	A	SA
O9.	The inadequacy of a student's mathematics background can be overcome by providing contents of mathematics from the history and the prescribed textbooks.	SD	D	N	A	SA
O10.	When a low-achieving student progresses in mathematics, it is usually due to the teaching through extra historical mathematics materials.	SD	D	N	A	SA
P11.	I understand the contents of HM well to teach mathematics effectively.	SD	D	N	A	SA
O12.	The teacher is generally responsible for the achievement of students in mathematics to make a creative pedagogy using HM.	SD	D	N	A	SA
O13.	Student's achievement in mathematics is directly related to their teacher's effectiveness of teaching mathematics through HM.	SD	D	N	A	SA
O14.	If parents comment that their child is showing more interest in mathematics, it is probably due to the use of original mathematical texts by the teacher.	SD	D	N	A	SA
P15.	I will find it difficult to use historical examples to explain to the students why mathematics works.	SD	D	N	A	SA
P16.	I will typically be able to answer students' questions using historical facts, stories and examples to motivate and convince them.	SD	D	N	A	SA
P17.	It will be wonderful if I have the necessary skills of using history to teach mathematics.	SD	D	N	A	SA
P18.	Given a choice, I will deny the presence of anybody to observe and feedback my mathematics history-oriented teaching.	SD	D	N	A	SA
P19.	When students have difficulty in understanding a mathematical concept, I will usually use games inspired by HM to help them understand it better.	SD	D	N	A	SA
P20.	When I teach mathematics, I will usually welcome students' questions through old mathematics problems.	SD	D	N	A	SA
P21.	I know I will be able to turn students on to mathematics by using biographies and contributions of premier mathematicians into mathematics.	SD	D	N	A	SA