Reliability and Validity of the Instrument Measuring Values in Mathematics Classrooms

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ABSTRACT

Values in mathematics classroom is not commonly discussed, researched, implemented, and measured although value is a significant affective aspect of mathematics learning. In this article, it is proposed that an instrument is developed to measure the said values which will benefit the teaching and learning mathematics. Discussion will focus on the reliability and validity of the sub-constructs and the instrument. The instrument consisted of 36 items with three sub-constructs, namely the general education values, mathematics education values, and mathematics values. Each of the sub-construct is represented by several dimensions. Data was collected from 325 lecturers of 17 matriculation colleges in the country. Descriptive statistics, reliability statistics for the construct, sub-constructs, and dimensionsand item analysis comprising ofinter-item correlation, item-total correlation, and Cronbach's alpha value when item was deleted were demonstrated. The proposed framework theoretical structure was checked for uni-dimensionality using Principal Analysis Residuals and several fit indices usingConfirmatory Factor analysis. The Cronbach Alpha values for the construct, three sub-constructs, and nine dimensions were found to be reasonably high. Results from the higher order Confirmatory Factor Analysisindicated that the structure of the general education values and mathematics values did not portray an acceptable goodness of fit. Only the values in mathematics education were found to have acceptable goodness fit values. Item analysis indicated thatitems have good correlation with other items and acceptable item-total correlation amongst items within the sub-construct, construct, and the nine dimensions. Principal Analysis of Residuals results indicated that there is a possibility of the mathematics education and mathematics values to be uni-dimensional. The instrument may provide more knowledge on values development in mathematics classrooms. However, in depth research focusing on the dimensions and value indicators was advisable besides executing the study on a larger sample in order to gain more information on the reliability and validity of the instrument.

Keywords: *reliability, item analysis, construct validity, uni-dimensionality*

INTRODUCTION

Mathematics curricula have been seen as a valuefree subject, focusing mainly on skills and techniques for decades (Nik Azis, 2009). Value which is an affective aspect is a significant contributor towards the teaching and learning of mathematics (Seah, 2002) especially in establishing students' sense of personal and social identity. It is more stable if compared to others affective constructs like beliefs, motivation, attitudes and anxiety. Value is also an inherent part of educational process at various levels including the system, institutional, curriculum development, management, and classroom interactions. The development and reformation of education system in Malaysia has always included values education as part of the Malaysian educational curriculum as being stated in the National Philosophy of Malaysian Education (NPME). Sixteen moral values were introduced and expected to be taught or inculcated through all subjects offered in schools.

LITERATURE REVIEW

Value was a relatively new area of research interest from the context of mathematics education as compared to other affective constructs such as beliefs, attitude, motivation, attitude, and perceptions (Seah & Bishop, 2000). Furthermore, teaching mathematics most of the time was aimed at acquisition of knowledge while giving minimum emphasis on the affective domain such as values (Bishop, 1988). In reality, mathematics is a field of study with various values taught implicitly rather than explicitly during lessons. Values were known as an influential factor on teachers' and students' decisions and behaviors related to mathematics (Corrigan et al., 2004) affecting their interest, thoughts, choices and behaviors towards mathematics education (Seah, 2002).

Definition of values in mathematics education was often attributed to the earlier socio-cultural definitions constructed by Bishop (1988) where values were considered as deep affective values (Bishop, 2007). Seah and Bishop (2000) proposed that mathematics education values constituted of five complementary pairs: formalistic versus activist view (Dormolen, 1986), instrumental versus relational understanding (Skemp, 1979), relevance versus theoretical nature of mathematics teaching and learning, accessibility versus specialism of mathematics knowledge, and utilizing mathematical skills as part of a process versus as a tool. Dede (2009) categorized mathematical education values as positivist and constructivists referring to teaching mathematics in an abstract manner, without relating it to the real life as compared to teaching mathematics concretely and relates it to the real-life experiences. The conception of values in mathematics education defined by Nik Azis included both the physics and the metaphysics elements based on the work of Al-Ghazali (1990) and Syed Muhammad Naquib (1995). The scope of the integrated perspective covered not only classrooms but also personal, institution, epistemology, society, nation and the community. Nik Azis suggested a list of hierarchal values for the components under mathematics education and mathematics values instead of following Bishop's complimentary pairs of values.

Several prominent researchers have attempted to develop tools which could measure values in mathematics education and mathematics as a subject such as: Mathematics Values Instrument (Bishop, 1988), Mathematics Values Scale (Durmus & Bicak, 2006), and Mathematics Education Values Questionnaire (Dede, 2011). Bishop, Clarke, Corrigan and Gunstone (2005) designed an instrument to learn more on teachers' preferences and practices regarding values in teaching mathematics and sciences. On the other hand, the Teachers' Beliefs Survey (Beswick, 2005a) touched on measure teachers' consistency with a problem-solving view of mathematics and corresponding views of mathematics teaching and learning. The Mathematics Values Inventory (MVI) focused on mathematics values in terms of the achievement-related choices which focus on students' beliefs in the area of interest, general utility, need for high achievement, and personal cost (Luttrell, Callen, Allen, Wood, Deeds, & Richard, 2010). Other instruments were instruments developed by Durmus and Bicak (2006) and Dede (2006 & 2009) from Turkey which categorized the values of mathematics and mathematics education into teachers and students centered values.Currently there were only two research in Malaysia, one is on teachers' understanding, perceptions and beliefs on mathematics values (Wan Zah, Sharifah Kartini, Habsah, Ramlah, Mat Rofa, Mohd Majid, and Rohani, 2005) and mathematics secondary school teachers' beliefs and their instructional practices Wan Zah, Sharifah Kartini, Mat Rofa, Habsah, Rohani,Ramlah, and Mohd Majid, (2009).

The discussion above indicated that the conceptual framework of values used in the existing studies were based on the system, social and cultural of the Western following the definition proposed by Bishop (1988) which do not include the spiritual and religion aspects. Thus, the instruments are not suitable to be used in Malaysia since the National Education Philosophy of Malaysia is based on faith and religion as being stated in the Rukun Negara or the National Principles of Malaysia. This suggest that there is a need to have develop an instrument based on holistic approach, taking into consideration the meta physic aspect.

THEORETICAL BACKGROUND

The Malaysian education system will need an instrument which is suitable with the National Education Philosophy where belief and faith is the underpinning values of education. The study proposed a conceptual framework based on the universal integrated perspective which is a faith-based perspective introduced by Nik Azis (2009). According to this perception, value was believed to exist in the human soul, constructed in the minds, obtain its meaning in the heart, operated in the soul and manifested through behavior, mental, cognitive and spiritual. Values which occurred during mathematics education were judgment on the importance, utility, prioritizing, experiences, phenomenon, or actions based on certain principles, guidance or standards. Ultimately, these values influenced decisions in executing mathematics activities or determining things to be appreciated in mathematics education.

OBJECTIVE

The specific aim of this study is to present the four findings related to the construct validity of the newly developed instrument measuring values in mathematics classrooms. The findings include: (a) reliability of the instrument, sub-constructs, and dimensions, (b) items analysis, (c) dimensionality of sub-constructs, and (d) confirmation of the structure conceptual framework. The reliability checks were done using the internal consistency reliability by analyzing the Cronbach's Alpha values. Inter-item correlations, item-total correlations, and Cronbach's alpha if item is deleted were used to conduct item analysis for the instrument. Principal component analysis of the residuals (PCAR) was used to study the dimensionality of the sub-construct and Confirmatory Factor Analysis (CFA) was used to determine whether the hypothesis of the conceptual framework is acceptable in measuring values in mathematics classrooms.

STUDY DESIGN AND METHOD

Survey questionnaire was administered to purposively sampled 325 mathematics lecturers from 17 matriculation colleges. Majority of the lecturers have degree in their respective subjects. There were 93 (28.6%) male and 232 (71.4%) female lecturers in the sample in which more than 150 of the lecturers have teaching experience of more than 10 years. The researcher used an accepted rule in which 10 subjects were recommended for each item (Nunnally's, 1967), although there were other researchers who suggested a ratio as small as 5:1 (Hatcher, 1994).

THE INSTRUMENT

The self-report instrument which consisted of 36 items measuring values in mathematics classrooms was conceptually hypothesized to have three sub-constructs following the categorization by Bishop (2008). The three sub-constructs were the general education, mathematical education, and mathematics values. The general education values had four dimensions, namely the basic, core, main and expanded values as suggested by Nik Azis (2014). The mathematics education values had two dimensions which were the teaching and learning values (Bishop, 1988 & Nik Azis, 2014). On the other hand, the mathematics values was made of three dimensions which were the ideology, sentimental, and sociology. Each of the sub construct contained 18, 8, and 10 positively written items respectively. The instrument was written in English and was based on a five-point scale where each rating has a weight attached to it: strongly disagree (1), disagree (2), somewhat agree (3), agree (4) and strongly agree (5). The instrument went through the process of checking for content validity by using a focus group followed by panels of experts before checking the construct validity.

CHARACTERISTICS OF THE DATA

Skewness and Kurtosis values were used to determine normality of the construct, sub-constructs, dimensions, and the items. The skew values were found to be bigger than -2 and smaller than 2 (George & Mallery, 2010) and none of the kurtosis values was greater than 7 (West et al., 1995) for the construct, sub-constructs, and dimensions which indicated the data were all normally distributed. Furthermore, since the sample size is 325, which exceeds 200 cases it reduced the risk of problems associated with skewness and kurtosis in data sets (Tabachnick & Fidell, 2007).

FINDINGS AND DISCUSSIONS

The findings focus on the construct validity, the degree to which the items on an instrument relate to the relevant theoretical construct (DeVon et al. 2007). It also includes findings on dimensionality of subconstructs and confirmation of the conceptual framework structure.

Reliability Measures

The internal consistency for this instrument was established using Cronbach's coefficient alpha, computed for each sub-construct and dimension (DeVon et al. 2007). Table 1 demonstrated alpha values for the general education values (GEV), mathematics education values (MEV), mathematics values (MV) and values in mathematics classrooms (ViMC)to be .918, .882, .882, and .952 respectively. Cronbach's alpha for the nine dimensions ranged between .675 and .932.

Table 1 Cronbach's Alpha Values for the Sub-Constructs, Construct, and Dimensions

		Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items.	N of Items
Constructs	ViMC	.952	.953	36
Sub-constructs	GEV	.918	.920	18
	MEV	.882	.887	8
	MV	.882	.887	10
Dimensions	Basic	.932	.933	5
	Core	.760	.760	4
	Main	.768	.782	4
	Developed	.838	.839	5
	Teaching	.771	.777	4
	Learning	.853	.854	4
	Ideology	.815	.815	4
	Sentimental	.718	.717	3
	Sociological	.675	.683	3

Item Analysis

The analysis covered inter-item relation, item-total correlation, Cronbach alpha values (when respective item is deleted), and item-total statistics for item analysis. The inter-item statistics for each item ranged from .094 to .823 and were all positive values, an indication that items fit together conceptually (DeVon et al. 2007). High inter-item statistics would indicate that each of the items is not contributing something unique to the construct, and therefore, suggesting multi dimensionality and low inter-item statistics would indicate non-discriminating items. However, in this sample there wasn't any case in which the combinations of Cronbach's alpha coefficient value and mean inter-item correlation were both in the unacceptable range.

Table 2 demonstrated that the item-total correlation amongst items within the sub-construct, construct, and the nine dimensions were found to be acceptable, as majority of the items had good correlation with other items except for a few exceptions with having either lower or too high of the correlation values indicating not highly correlated or redundant respectively. The item-total correlations were seen to be within .30 to .70 and can be considered acceptable (de Vaus, 2004) besides having at least 50% of the retained items with total scores in the range of .30 and .70 (Carmines & Zeller 1974).

Table 2 Summary of Item Reliability Analysis for Construct, Three Sub-constructs and Nine Dimensions

	Inter-Item Correlation	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	N of Items
ViMC	.094 to .823	.448 to .651	.949 to .951	36
GEV	.147 to .823	.487 to .673	.911 to .916	18
MEV	.360 to .714	.579 to .730	.860 to .876	8
MV	.296 to .604	.528 to .687	.866 to .878	10
Basic	.430 and .70	.781 to 860	.909 to .925	5
Core	.340 to .590	.495 to .571	.667 to .737	4
Main	.300 - .660.	.412 to .642	.676 to .814*	4
Developed	.378 to .691	.573 to .715,	.784 to .823	5
Teaching	.412 to .586	.530 to .609	.697 to .742	4
Learning	.489 to .714.	.670 to .694	.792 to .825	4
Ideology	.446 to .601	.480 to.538	.552 to .696	4
Sentimental	.382 to .534	.480 to .597	.552 to .696	3
Sociological	.364 to .478	.449 to .542.	.506 to .645	3

The instrument corrected item total score varies in the range .448 to .651 indicating good relationship of items with the construct, sub-constructs, and dimensions.

Table 3 Item-Total Statistic: Item and Values in Mathematics Classrooms

Code Value Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
NUA1 Attention to values	148.63	191.159	.505	.950
NUA2 Respond to values	148.72	189.728	.515	.950
NUA3 Evaluate values	148.78	189.210	.552	.949
NUA4 Build value system	148.75	188.223	.579	.949
NUA5 Act out values	148.69	190.043	.535	.950
NUT1 Fulfilling life needs ethically	148.99	190.636	.478	.950
NUT2 Fulfilling safety needs	149.04	188.551	.542	.950
NUT3 Wisdom	148.77	189.863	.553	.949
NUT4 Justice	148.75	188.817	.628	.949
NUU1 Discipline	148.64	190.193	.635	.949
NUU2 Teamwork	148.60	192.215	.551	.949
NUU3 Accountability	148.72	190.387	.607	.949
NUU4 Innovativeness	149.04	189.458	.551	.949
NUK1 Culture of knowledge	148.70	190.420	.617	.949
NUK2 Culture of diligence	148.64	191.045	.611	.949
NUK3 Culture of quality	148.71	190.219	.646	.949
NUK4 Culture of precision	148.65	191.716	.538	.950
NUK5 Culture of integrity	148.71	189.835	.634	.949
PMP1 Teach for higher mathematics	148.82	189.513	.556	.949
PMP2 Teach for functionality	148.90	188.525	.613	.949

PMP3 Teach to generate knowledge	148.68	191.612	.577	.949
PMP4 Teach to internalize knowledge	148.77	189.133	.642	.949
PMB1 Learn for mastering skills	148.58	190.936	.629	.949
PMB2 Learn for processing	148.71	189.694	.631	.949
PMB3 Learn for constructing	148.68	190.452	.628	.949
PMB4 Learn for obtaining knowledge	148.62	191.278	.598	.949
NMI1 Rationalism	148.79	188.925	.621	.949
NMI2 Empiricism	148.96	188.449	.642	.949
NMI3 Pragmatism	148.77	190.092	.579	.949
NMI4 Integrated	148.85	189.799	.624	.949
NMS1 Control	148.82	190.756	.531	.950
NMS2 Development	148.95	189.593	.582	.949
NMS3 Civilization	148.84	189.738	.607	.949
NMC1 Separated	148.77	189.629	.651	.949
NMC2 Openness	149.34	189.095	.448	.951
NMC3 Integrated	149.10	188.037	.553	.950

Most items appeared to be worth of retention since deleting items from the construct, sub-constructs, and dimensions lowered the respective Cronbach's alpha.Only one item which was "innovativeness" in the general education values produced higher Cronbach's Alpha values when deleted, the rest of the items produce smaller values.

Dimensionality of Sub-constructs

The uni-dimensionality of the three sub-constructs were determined by examining the unexplained variance in the first contrast. A secondary dimension exists if the unexplained variance of the first contrast has a strength of at least three items. Principal component analysis of the residuals (PCAR) provided information on whether a substantial factor exists in the residuals after the primary measurement dimension had been estimated (Linacre, 2007).

Table 6 Summary of the Standardized Residual Variance (in Eigenvalue units)

Construct and sub-constructs	Raw variance explained		Unexplained variance in 1st Contrast	
	Eigenvalue	Empirical	Eigenvalue	Empirical
General Education Value	21.8	54.7	3.8	9.6
Mathematics Education Value	9.7	54.7	1.6	9.2
Mathematics Value	12.1	54.7	2.1	9.3

Eigenvalues of unexplained variance in 1st contrast was more than 3 for general education values which was an indicative of an existence of another dimension and less than three for mathematics education values and mathematics values which indicated uni-dimensionality within these constructs. The items in each sub-construct explained a total of 54.7% of the variance which was considered high. The PCAR results showed the multidimensionality for the general education due to the high eigen-values (more than 3.0) for the unexplained variances indicating the existence of a second dimension and possibility of unidimensional for mathematics education values and mathematics values.

Confirmation of the Conceptual Structure

This study used Confirmatory Factors Analysis (CFA)to test the theoretical knowledge postulated between values in mathematics classrooms and the underlying sub-constructs. The first order Confirmatory

Factors Analysis referred to how the dimensions loaded into the respective items, while the second order was employed to validate how the theorized sub-constructs loaded into its dimensions (Kline, 2005).

The factor loading for the first order constructs varied between values of .57 to .90 for general education values. This indicate that the general education value is probably not unidimensional and do not conform to the conceptual structure proposed. The CFA analysis performed on the general education valuesdemonstrated a poor goodness of fit. The χ2/dfwas 3.64; the comparative fit index (CFI) was .898; and the adjusted goodness of fit (AGFI) was .894, the Tucker-Lewis coefficient (TLI) was .884, and the root mean square error (RMSEA) value was .879. Although the values of GFI, CFI, and TLI for example were quite high, none of the given values reach the permitted threshold accepted which was >.90.

The goodness fit indices for the mathematics education values, on the contrary were found to be at an acceptable level where chi square/df = 3.97, CFI = .952, GFI = .944, AGFI = .894, TLI = .929, and RMSEA = .096. The path coefficients vary from .62 to .83 for the mathematics education values confirmatory factor analysis and were all above .50. The factor loading for the second order constructs were .85 and .93 which reflected that the theory that mathematics education values consisted of the dimensions of teaching and learning were well supported and conformed to the theory and previous research.

The fitness indices for mathematics values showed that chi square/df = 7.57, GFI = .890, AGFI = .816, CFI = .832, NFI = .813, TLI = .771, RMSEA = .142, and RMR = .312 indicated that the mathematics values was not fit. However all measurements of the first order factor loading for the three dimensions: ideology, sentimental, and sociological values were found to be .98. The mathematics values were made up of three dimensions were not supported for this sample. Table 5 displays the fit indices used in Confirmatory Factors Analysis for the three sub-constructs.

Table 5 Comparisons of Fitting Indices

	cim/df	p-value	GFI	AGFI	CFI	TLI	RMSEA
GEV	3.64	.000	.856	.816	.898	.884	.090
MEV	3.97	.000	9.44	.894	.952	.929	.096
MV	7.56	.000	.890	.816	.832	.771	.142

IMPLICATIONS OF STUDY

Firstly, the instrument demonstrated acceptable psychometric properties. The study showed that the construct, three sub-constructs, and nine dimensions have high reliabilities. The item analysis indicated that the items contributed significantly to the instrument although there are cases that the inter-item correlations within the sub-constructs and dimensions were either too low or too high. The study indicated that the hypotheses of conceptual structure is supported for the mathematics education values but not supported for the general education values and the mathematics values. The goodness of fit for both the general education values and the mathematics values were suggesting that the sub-constructs needed some improvements. However, the mathematics education values indicated a possibility of being uni-dimensional. This call for a study to be done in which values indicators were probably decided upon after running the Principal Component Analysis.

One of the limitations of this study was the construct validity reported was mainly derived from a homogeneous sample. Further validation of the scale is necessary to replicate the study in a heterogeneous sample such as lecturers in higher learning institution, mathematics teachers in primary and secondary schools, pre-service teachers, and policy makers in education system. A second limitation is the respectively small size sample. The theoretical structure in this study may hold in future administration of the research for a larger sample size. The third limitation was the fact that the instrument was for mathematics in general. The instrumentcan be refined by replacing mathematics with specific focus from branches of mathematics such as arithmetic, calculus, and statistics. It can also be modified to assess values in teaching and learning other subjects such as sciences and accounting. This theoretical based instrument provided empirical findings which is a catalyst for more research to be done in the area of values development in mathematics classes.

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