The Mathematics Values In Classroom Inventory: Development And Initial Validation

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ABSTRACT

Value has been identified as an essential aspect towards the quality in mathematics education at various levels of the system, institutional, curriculum, education management, and classroom interactions. However, few studies were focused on values, its development, measurement, and impact in education as compared to other affective aspects such as beliefs, motivation, perceptions, and attitude. In addition, most studies dealt with values developed in Western education setting where the spiritual domain was not considered. This paper detailed the instrument development processes including analysis, design, development, and evaluation phases. Content validity of the 36-item instrument was enhanced by a focus group and panels of experts' reviews. Construct validity was investigated using reliability measures, item analysis, principal analysis of residuals, rating scale functioning, confirmatory factor analysis, and first order factor analysis. The inventory, three sub-constructs, nine dimensions, and the 36 items have high Cronbach alpha values. Confirmatory factor analysis did not fully support the hypothesised conceptual framework with three sub-constructs and nine dimensions. Suggestions on how to further improve the instrument validity were proposed. The instrument which was theoretically based on faith and belief in God, was the pioneer and significant to the future investigations on values development in mathematics education.

Keywords: *Instrument development; universal integrated approach; values development, validity.*

INTRODUCTION

Integrating values in the teaching and learning mathematics has not been an easy task for teachers, since it would require for the teachers to know important values to be integrated and how to develop them in classrooms. Currently, the quality of values development and ethics in mathematics education in Malaysia remained at low level and the activities conducted were not exhaustive and not integrated. We were still far from fulfilling the pinnacle of values development which is to produce civilized individuals who would act and behave appropriately according to specific guidelines and able to make righteous decisions in critical situations (Nik Azis, 2014).

Literature Review

Literature showed that there was little agreement on the conceptions of values as well as its categorization. Conceptualizations of values were normally based on the context of usage, suggesting that a single definition may not suit the many arising situations concerning values. Adding to the complication was the situation where conceptions and constructs were sometimes borrowed from other fields like psychology and sociology while ignoring the basic assumptions of the constructs. Among the popular definitions were:

values as ideal culture with the focus on evaluation Rokeach (1973), values from the context of relativism epistemology where man was the authority in evaluating and determining values (Raths, Harmin & Simon, 1966), and values as sociological factors especially on principles and standards used to guide human behaviour (Halsted & Taylor, 2000). Values in mathematics classrooms were often attributed to the earlier socio-cultural definitions constructed by Bishop (1988) where values were considered as deep affective values. The conceptions were mainly developed in the context of the western education culture unlike the definitions proposed by Nik Azis (2009) which took into consideration the metaphysical aspect.

There were limited studies in the area of values in mathematics education and its development since value was relatively a new area of research interest as compared to other affective constructs such as beliefs, attitude, motivation, and perceptions (Seah & Bishop, 2000). In addition, teaching mathematics was usually aimed at acquisition of knowledge while providing minimal emphasis on values in mathematics education (Bishop, 1988). Furthermore mathematics had been taught as a subject which was value free by teachers, employers and parents (Bishop, FitzSimons, Seah, 1999).

There was also issue on availability of instruments measuring values in mathematics classrooms. Several prominent researchers had 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, 2005) 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 included 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 centred values.

Although instruments had been developed to measure values in mathematics classrooms, they were unsuitable for the Malaysian education purpose as they were designed based on psychological theories which were secular in nature. This was due to the fact that these instruments were developed in western culture which served the western needs where faith and belief in God were separated from daily activities. Furthermore, these instruments were mainly focusing on perceptual studies where the scope were limited in breadth and depth.

Conceptual Framework of the Values in Mathematics Classrooms

In the context of classroom settings, values in mathematics education were categorized into the universal values, mathematical education values and mathematics values where each one was further represented by several dimensions of values (Nik Azis, 2009). Bishop (1988) suggested that assessment of values was to detect the leading values between two complementary values leading towards balancing of the two complementary values for the sub-constructs. Nik Azis detailed out the work done by Bishop (1988) from the perspective of universal integrated approach by representing the dimensions of the sub-construct in a hierarchal manner.

The universal integrated perspective which was based on believing in God referred values as conceptions and beliefs of individuals concerning the importance of something which act as general guides to their behaviours (Nik Azis, 2008, 2014). The conceptions of construct were based on the basic definitions on values and ethics development according to the teaching of Islam which were systematically structured by Syed Muhammad Naquib (1995). The conception follows definition provided by Al-Ghazali (1990) where value was conceptualized as an intellectual discipline, known as adab. It was referred as the appreciation and acknowledgement of the reality that knowledge and human hierarchically were ordered according to certain grades and degree of rank, and of one's proper place in relation to reality and to one's physical, intellectual, and spiritual capacities and potentials.

In terms of the sub-constructs, values in mathematics classrooms were categorized into universal values, mathematical values, and mathematics values. Universal values which were values contributed towards the formation of a good human with good characteristics while mathematics education values were values related to effective learning and teaching. Mathematics values on the other hand were related to the sources, limitations, and reliability, on the truth of mathematics as one of the discipline in knowledge within a particular culture. Bishop's work did not include conceptual definition for the universal values. The universal values proposed by Bishop was associated with the norms of an educational institution within a particular society which had a particular culture. Nik Azis (2016) expanded the definition of universal values following the Hierarchy Categories of Values Model in which faith was proposed to be the fundamental values (values as guidance in life), followed by the core (values as necessity in life), main (values portraying oneself) and development (self-development values). The mathematics education values were divided into the values in teaching and learning. Teaching was categorized into teach for higher mathematics, teach for functionality, teach to generate knowledge, and teach to internalize knowledge. Values for learning included learning for mastering skills, learning for processing information, learning for construction of knowledge, and learning for obtaining knowledge. The mathematics values were being categorized as ideological, sentimental, and sociological aspects. Ideology consisted of items related to rationalism, empiricism, pragmatism, and integrated values, while the sentimental values had control, development, and civilization. The sociological aspect of mathematics consisted of items describing separated, openness, and integrated values. The pragmatism and integrated approach were added into the ideological aspect suggested by Bishop. Civilization was another value added to the control and progress values from Bishop's sentimental values and the value of integrated was added to the sociological aspects which initially consisted of mystery and openness.

Research Objectives

This paper is intended to demonstrate the process of developing an instrument measuring values in mathematics classrooms based on the universal integrated perspective. Developing an instrument able to measure values in mathematics classrooms which is based on belief in God and faith would lessen the gap in knowledge on development of values in mathematics education. The study is aimed to answer the following research questions: (a) What are the sub-constructs, dimensions and values indicators suitable to measure self-perceptions of values in mathematics classrooms of lecturers from pre-university colleges? (b) What is the suitable design of the instrument to be used? and (c) What are the validity and reliability of instrument in measuring values in mathematics classrooms?

METHODOLOGY: THE ADDE MODEL

This study employed an instrument developmental design involving qualitative and quantitative research approaches to develop and validate the instrument measuring values in mathematics classrooms. The ADDE model which stands for the analysis, design, development, and evaluation phases of the development process was adopted from an approach used by instructional designers and content developers in order to create instructional course materials with the implementation stage being dropped. The stages, the four phases, main focus, activities, and types of data involved throughout the process were summarized in Table 1.

Table 1 ADDE Model

Stage	Phase	Main focus	Activities	Types of Data
Identification	Analysis	Problems identification	Identifying issue or problem Purpose and reseach questions	Qualitative
		Conceptual Framework	Theoretical framework Defining constructs, sub constructs, dimensions and value indicators	Qualitative
Generation	Design	Design of scale	Scaling and instrument format Item pool Formula for scaling Instructions for respondents	Qualitative
	Development	Checking	Focus group Check and improve the item pool Panel of experts Re-checking and refining items	Qualitative
Confirmation	Evaluation	Determining validity and reliability	Pilot study Field work	Quantitative Quantitative

The process started with the researcher surveying literature related to values, values development, and construction of instruments. It was during this process that issues, current research interest and directions, research questions, conceptions of constructs, theory being used, instruments available, targeted samples, validation and reliabilities studies, and statistical tests were identified. The design phase included activities such as instrument format, formula for scaling, and constructing initial item pool. The developmental phase involved focus group, the process of checking and improving the item pool, involvement of experts, and refining items using feedback obtained. The fourth phase involved pilot study and field work in which several statistical tests were used to check on the construct validity.

Development Framework

Table 2 describes the data collection method, instruments used, samples and techniques of data analysis for the four phases of the ADDE model together with the brief explanations on the activities at each phase.

Table 2 Data Collection Methods, Instruments, Samples, and Data Analysis Techniques

Phases	Activities	Method of Data Collection	Instruments	Sample	Techniques of Data Analysis
Analysis	Analysis	Review of Literature	Document Analysis Protocol	Eight instruments	Qualitative Content Analysis
Design	Analysis	Review of Literature	Document Analysis Protocol	Literature	Qualitative Content Analysis
Development	Focus Group Interview	Group Interview	Instrument for Focus Group (Survey and interview protocol for focus group)	Seven lecturers from a preparatory college in Selangor	Simple Descriptive Analysis Protocol Analysis
	Experts Feedback	Closed and Open Ended Survey	Survey	19 experts	Simple Descriptive Analysis
Evaluation	Pilot Study	Survey	Self-report Questionnaire	241 lecturers from Public University	Descriptive and Inferential Analysis\
	Real Study	Survey	Self-report Questionnaire	325 matriculation college lecturers	Descriptive and Inferential Analysis

Various data collection methods were used at different phases, which included analysis of instruments found in the literature, group interviews, and survey. Five instruments including document analysis protocol, survey and interview protocol for the focus group, closed and open ended survey for the experts and self-report perception survey for the targeted samples were used at different stages in the study. Six related instruments were analysed during the analysis phase, current literature were analysed during the design stage, seven lecturers were involved in the focus group, 19 experts were consulted, 241 lecturers were involved during the pilot study and another 325 lecturers were involved in the real study.

Data analysis techniques such as qualitative content analysis, simple descriptive analysis and protocol analysis were used for data from the focus group and experts' feedback and descriptive and inferential statistical analysis were used for the pilot and real study.

DISCUSSION

The findings were discussed according to the four phases, starting with analysis, design, development, and evaluation phase.

Analysis Phase

Six instruments measuring values related to teaching and learning mathematics were analysed. The socio cultural approach, constructivism, and expectancy-value theory were among the theories used. However, the sub-constructs used to measure the values were conceptually defined according to the theory, however, there wasn't a structured explanation from the aspect of the ontological, epistemology, axiology and logic of them. Furthermore, these theories were from the western cultural in which the mathematics knowledge were developed, where elements of metaphysics were not taken into consideration. The instruments subscribed to different sub-constructs and dimensions according to their conceptions definitions of the construct. The conceptual definitions of values in mathematics classrooms and the sub-constructs have not reached a consensus and are still open for discussion since efforts in the area were considered very limited. The conceptual definitions provided by Bishop (1988, 2008) were commonly used by researchers studying values in mathematics education in Australia, Turkey, and Taiwan.

Rating scale was found to be commonly used to measure the latent values. However, interviews and observation were used in order to study the values one has and how these values were espoused to students. The six instruments did not provide detail work on efforts relating to the validity and reliability of the instrument. However, Dede (2006), Luttrell et al. (2010), and Liman et al (2012) demonstrated some process in enhancing the face, content, structure, criterion and convergence validity and reliability test for their instruments. Lutrell et al. was the only author who detailed out his extensive study on the face, content, and construct validity. Only Durmus and Bicak ventured into using the principal component factor analysis in order to confirm construct validity. Lutrrell et al. (2010) dealt with language validity to ensure that the instrument is free from misinterpretations. None of the researcher used item analysis in order to check on individual item. Target groups were found to be mainly students, pre-service teachers and teachers from primary and secondary schools and also university students. No study has been done for policy makers or curriculum designer of mathematics study.

Design Phase

The instrument used a 5 point Likert scale in which the options indicated intensity of their responses. Weightage were given for each of the responses, for example in this study a five-point scale was used where strongly disagree (1), disagree (2), somewhat agree (3), agree (4) and strongly agree (5). Rating was favourably used since it was most suitable in measuring latent trait variables like perceptions towards values in mathematics classrooms. The instrument was divided into three parts, the instruction, the demographic profile section, and the questionnaire. Age, gender, academic backgrounds, social backgrounds, duration of service, and interest in mathematics were among the information being collected. The instruments were prepared in both English and Malay versions. Objectives of the instrument, the meaning of each of the rating scale, and were provided in both languages. There were 36 items where 18 from the general education values, eight from the mathematics education values, and ten from the mathematics values. Besides finding the total score for the values in mathematics classrooms, each of the three sub-construct and dimension can be measured separately by finding their respective average scores.

Development Phase

The instrument went through two stages of content validity enhancement processes which were the focus group interview and evaluation by panels of experts. Seven lecturers from a local university with similar demographic background as the targeted sample were invited to participate in a focus group interview, where the initial pool of thirty-four (34) positive items were reviewed. A survey questionnaire and an interview protocol were used to collect the data from the aspect of the clarity, relevancy, and understanding of items. Data analysis for the focus group was done in both qualitative and quantitative manner. The quantitative data would be the perspectives of participants towards the items from the aspects of clarity, relevancy, language and understanding which were obtained from the Likert scale questionnaire. Out of all the total data for general education values, mathematics education values, and mathematics items (include items written in both English and Bahasa Malaysia), 17%, .07%, and .08% obtained mean below 3.5 for clarity, relevancy, and understanding of items. The qualitative data would be the comments written by the participants on specific items or important facts collected by the researcher during the session. Participants of the focus group provided their verbal and written feedbacks on how the items can be rephrased to avoid misunderstanding or confusion among the respondents. Items were rewritten, difficult terminologies were replaced, and long items were shortened following suggestions from the participants.

Out of 34 items only eight were remained unedited and the rest were edited before being sent to three panels experts. The first panel evaluated the relevancy, quality of the translation and whether the collection of items represents the respective dimension of the sub construct. The second panel focused on the difficulty, clarity, and readability level of the items and the third panel evaluated the format, presentation, allowance of time, general presentation and suitability of the instrument. The nineteen (19) experts who agreed to take part were from the area of mathematics, education, and mathematics education. Comments such as items were loaded, items were confusing, lengthy, with vague technical terminologies were received. Participants also raised the issue that the instrument might not be suitable for those who do not practice Islam.

Evaluation Phase

This phase discusses the early validation done to the instrument during a pilot study. Pilot study may increase the time duration of the research, however, it provided an opportunity for the researcher to reduce unanticipated problems. Items that lack clarity, not appropriate, and unable to discriminate between respondents were identified during the pilot study. The statistical analysis will assist the researcher to decide on whether an item should be deleted or improved. The pilot testing of the newly developed instrument emulated estimated timing of survey, logistic and estimated the costing involved as part of the validation process (Dillman, 2000).

Statistical analysis showed that the means of items were between 3.76 and 4.58 and since the sample was more than 200, the risk from being not normal was negligible so the researcher will still use parametric statistical tests, although the skewness indicated not normal. Cronbach's alpha values for the general education values, mathematics education values, mathematics values, and values in mathematics classrooms were .901, .870, .876, and .939 respectively. The Cronbach alphas for the nine dimensions were more than .70 except for the main value which had value of .680. Item-total statistics for general education values, mathematics education values, mathematics values, values in mathematics classrooms, and the nine dimensions were all more than .30, an indication that the correlations of each item with the respective sub-constructs, construct, and dimensions were strong. The values of Cronbach alpha when a respective item was deleted were generally found to be less than the Cronbach alphas for the general education values, mathematics education values, mathematics values, values in mathematics classrooms and even the nine dimensions with very few exceptions. The item reliability in relation to the construct and three sub-constructs were all more than .90 and the item separation reliability were all more than 2.0. The person reliability for construct and three sub-constructs were all more than .70 and the person separation reliability were more than 2.0 except for mathematics education value.

Item analysis using Rasch model, identified four items which were outside the accepted mean square and z- standard ranges, however there were not much difference in terms of the item and person reliability when the items were deleted systematically. The findings for Principal Analysis of Residuals (PCAR) were not supportive of the unidimensional of the scale since there was an indication that a second dimension existed. However, there was no evidence of the existence of sever construct-irrelevant factors although there were indications of existence of a second dimension from the PCAR test. Confirmatory factor analysis indicated that model fit suggested that the three factors did not provide good explanation of the MViC for this sample based on the fit indices for confirmatory factor models. The first order factor analysis demonstrated that the factor loadings of the path measurement model for sub-constructs and dimensions were all recorded to be above .5, which indicated goodness-of-fit of the model.

CONCLUSION AND IMPLICATIONS

The study produced a survey instrument to measure values in mathematics classrooms based on faith and belief in God. The integrated theory provides the instrument with holistic, balanced, and integrated conceptions of values. This helps in reducing the issues on volatility, uncertainty, complexity and ambiguity in values discussions.

This theoretical based instrument provides empirical findings for more research on the values indicators. As an example, researchers can go deeper in identifying better or more values indicators for the basic values and to have a meaningful understanding of dimensions in mathematics classrooms based on the integrated perspective.

The instrument can be further improved by including more items or improving the current item, include thorough analysis for items. More statistical test on dimensionality can be introduced such as the second order confirmatory factor analysis in order to further confirm the conceptual structural proposed for individual sub-construct. Targeted sample can be varied and to include teachers from primary and secondary schools. Besides that, the instrument can also be catered towards a specific branch of mathematics for example values in teaching trigonometric or calculus instead of mathematics in general.

In conclusion, the paper provided information useful for further item modification and future development. It is proven that the instrument is able to provide numerical evidence on values and values development which may contribute to quality teaching and learning of mathematics from the perspective of integrated in which faith and religion were taken into account.

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