

Validation of Value Scale Development (VSD) Theory for Student Mathematics Value (SMaV) Scale Development

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Abstract

Theoretical framework is essential in almost every field of research. It involves terms that are clearly defined to provide a particular perspective through which a topic can be examined. So, the theoretical framework for the SMaV Scale development directed the study to produce an effective means of measuring Students' Mathematics Value. Through the results of the validation tests conducted using R software packages, it was discovered that the scale is reliable and valid with the Root Mean Squared Error of Approximation (RMSEA) = ≤ 0.05 ; Root Mean Square Residual (RMSR) close to 0 and Turker-Lewis Index (TLI) > 0.9 (Hu & Bentler, 2009). Then concluded that the proposed theoretical framework known as Value Scale Development Theory (VSDT) for SMaV Scale development was found appropriate for any new scale development and so recommended to be used for future related studies.

Keywords: Construction, Student Mathematics value Scale, Theoretical Framework, Validation, Value Scale Development Theory

Introduction

The performance of students in Mathematics at the school certificate level as shown in Table 1, the West African Examination Council (WAEC) candidates' results from 2016 to 2018 (NBS, 2019). This revealed that in the past years, the students' performance in the West African Senior School Certificate Examination (WASSCE) has not been satisfactory. Out of

133,258 candidates that sat for the examination in 2016, 40,346 candidates passed and in 2018, 1,058,054 candidates passed out of 1,571,536 candidates at credit level and above. These figures represent 30.27 per cent and 67.32 per cent of candidates who sat for the examination and obtained credits and above in a minimum of five subjects including Mathematics.

Table 1: The Students' performance in the West African Senior School Certificate Examination (WASSCE)

West African Examination Council results. Statistics for Credits and above in Mathematics						
Year Examination	WASSCE School Candidates'			WASSCE Examination		Private Candidates'
	Total Number sat	Credits and above	%	Total Number sat	Credits and above	
2016	1,543,974	950,730	61.57	172,821	73,267	42.39
2017	1,558,452	1,108,657	71.13	133,258	40,346	30.27
2018	1,571,536	1,058,054	67.32	109,978	39,581	35.99

Data Source: National Bureau of Statistics (NBS).

The inconsistency in the performance of students at credit level requires that there should be means through which there can be constant improvement of students' performance in the subject. Seriously Addictive Mathematics (S.A.M) (2020) stated that some of these approaches are using physical objects, focusing much on the weaker topics of students (Math Learning Groups (MLGs)(2019), sharing

positive attitudes concerning mathematics (Levy, 2018), collaborative teaching and learning (Maria, 2021). Although the means are numerous, focusing on mathematics value is not so glaring. Also, most of the studies for establishing such means involved theoretical background and framework. So, the development of the Student Mathematics Value Scale (SMaV Scale) required the involvement of

theoretical framework. Hence, a theoretical framework was developed by this study.

The SMaV Scale Theoretical Framework

Theoretical framework is a means of defining key concept in a research and proposing the relationship between them. It gives direction to a study for appropriate interpretation, explanation and generalisation of the study (Vinz, 2020). According to Rush (2017), theoretical framework is a lens through which a topic can be examined and strengthened. Waldenu, (2021) termed theoretical framework to be a single formal theory in which a study can be understood and investigated. Framework helps to justify and explain a study to others. It also allows the research to measure the level of understanding of the study (Crawford, 2020). This is different from an empirical phenomenon that is completely based on observation or practical experience, rather than theory. It refers to a verifiable issue (Your dictionary, 2022; Connelly library, 2021).

To develop a theoretical framework, some bases like the problem statement, research questions and literature review are to be considered (Vinz, 2020). In addition, the development of an effective theoretical framework (Sacredheart, 2021) involves clear description of the framework, concepts, models or specific theories that underpin the study. Also, the researcher must point out the essence of choosing that particular framework, link methodology discussion to the theoretical framework, use present tense in writing about the theory and make recommendation for further studies concerning the study that the theoretical framework was used for. From the University of Southern California (USC) 2022, the structure that supports the theory of a research study is the theoretical framework. The development of the theoretical framework for SMaV Scale involved the following procedures.

Problem Statement: When a research study involves a theory, the theory must be supported or held by a structure that is known as a theoretical framework. So, as the study of the SMaV Scale development involves some theories, it is therefore pertinent for a structure

that supports the study to be developed. Meanwhile by experience, there is yet to be available a value scale development theory that has the involvement of the three theories that were involved in this study. Therefore, it is required that a theoretical framework be rooted in at least a theory, SMaV Scale theoretical framework inclusive. But, an exact value scale development theory is not common to come by. Hence, this study developed a theory (structure) for the SMaV Scale development.

Objective: Some of the key concepts in the development of SMaV Scale are mathematics value, value orientation, construction and validation of the items in the scale. So, this study was proposed as a means of defining the key concepts and discovers the relationship between them. Simply, to get a single formal theory (theoretical framework) for SMaV scale development and such related studies.

Research Questions

Research Question 1: Is value scale development (VSD) theory able to explain the construct of students' mathematics value scale?

Research Question 2: Is there any good-fit existing between the proposed (VSD) theory and the SMaV Scale observed data?

Formation of Value Scale Development (VSD) Theory for SMaV Scale Theoretical Framework

The formation of VSD theory for SMaV Scale involved the two major endogenous (Value and Value orientation) variables for the study. The constructs can be traced to different already-existing theories. The constructs are value, value orientation and validation of the two constructs. Therefore, three theories that are related to this study are the Value Theory, the Value Orientation Theory and the Generalisation Theory.

Value Theory

The Value Theory was propounded by Aristotle. According to Forgatory (1991), value theory stated that need is what brings about exchange and there are two uses of everything we possess: value in use and value in exchange. That is, you can use the value you possess and you can

exchange it to meet your need. Relating this to mathematics implies that any learner of mathematics may acquire the skills of solving problems for use, either in solving personal problems and other people's problem. Such a person may use and exchange the problem-solving skills for money or other materials in order to solve his own problem. As problem skills are means of getting a need, so it is a value in mathematics. The value a student develops or acquires in mathematics may be in use by the student and or in exchange for other people's needs to be met. In Philosophy, value theory can be used in more than three ways. For instance in moral philosophy, value theory involves the asking of questions like how and why people value something (Research Guides, 2022).

Furthermore, there are other theories of value, like classical theories of value, marginal theory of value and Straffian theory of value. The classical theories of value involve Labour theory of value. David Ricardo in 1817 began the labour theory of value which stated that the relative quantity of labour required for the production of a commodity is value of the commodity. Karl Marx (1818-1883) who worked within the framework of Ricardo (Taylor, 1996), stated that the average number of hours required to labour for the production of an economic good is what measures the value of the economic good being produced (Kenton, 2021). This is similar to the labour theory of value propounded by Adam Smith which stated that it is the amount of labour that had gone into the production of goods that determines the value and the price of those goods (Horwitz, 2019). In Internet Public Library (IPL) (2022), the theory explained general price levels. The labour theory is based on production. In other words, the time and labour invested for the production of a good determines the value for that good (Taylor, 1996).

Within Ricardo's labour theory of value (theory of rent), neoclassical economists developed the Marginal Theory of Value. This states that physical measurement is required for measuring the marginal value of a particular thing. This relates to the development of SMaV Scale, in the sense that the scale would be a means for physical measurement of students' value in

mathematics and value for mathematics. In addition, Straffan's theory of value made it clear that there are periods of production (Taylor, 1996), and in the cause of production processes, all factors of production are used. This implies that for mathematics students to be improving in their mathematical performance when certain conditions that will enhance the expected students' performance are met in the processes of teaching and learning of mathematics, the usage of SMaV scale inclusive.

The Value Orientation Theory (VOT)

Another important theory that must be considered for the theoretical framework of SMaV scale development is Value Orientation Theory (VOT) which was proposed by Kluckhohn and Strodtbeck in the year 1961. They proposed that there are a limited number of worldwide known problems with few value-based solutions through different culture with different options among them. Kluckhohn and Strodtbeck suggested five different answers that can solve such problems (Hills, 2002). According to Hills (2002) people's orientation (attitude) are based on the relatively few, stable value they hold, the students' orientation towards mathematics can be influenced by the value they hold for the subject to help them fulfill in future. The five value orientations formulated by Kluckhohn & Strodtbeck in the year 1961 are human nature, relationship of humankind to nature, sense of time, activity, and social relationship. Through the formulated five orientations, they asked the following five questions that every society must answer: what is the relationship between humans and nature? What is the relationship between humans? What is the preferred personality? What is the orientation toward time? Not everyone in a society holds the dominant cultural values, so we should? (Hills, 2002).

Bot et al (2013) discussed that each of the five revealed and confirmed fundamental value orientations serves as belief system guiding physical educators' teaching behaviours. So, the value orientation: disciplinary mastery (DM), learning process (LP), self-actualisation (SA), self/social responsibility (SR) and ecological integration (EI) can help students' value

orientation perspectives to be positive and fulfilling. As cultural value orientations specify the ways people are expected to think, feel and act in order for the society to function smoothly, so mathematics value orientation specifically should make students think of how mathematics will make them valuable in the future. (Schwartz, 2014).

The current situation of students' performance in Mathematics is one of the common human problems for which all societies at all times must find solution. This is due to the importance placed on the need for every student to perform creditably in mathematics. Value orientation can be a means for such problems to be solved. Mathematics value orientation is an outward manifestation of the innermost values which the students, their parents or their teachers have been predisposed to with regards to having a good grasp of mathematics. For the value orientation to effectively resolve the challenges of the teaching and learning of mathematics there may be need for a diagnostic instrument for the formative evaluation of the students' mathematics value. In this case, SMaV Scale can serve as the appropriate measuring instrument that can enhance solution to the universal problem to which answer(s) must be produced.

As the value of courage is the catalyst of taking the desirable course of action (O'Connell, 2015), so mathematics students' courageous actions towards learning mathematics may be motivated or influenced by their age, gender, location, school type and parents. This may also enhance their ability to acquire value adding skills for future purposes, no matter how difficult mathematics seems to be. The students may be motivated in the direction of having high value orientation for Mathematics. SMaV Scale may be used as an eye opener for the skills embedded in the teaching and learning of Mathematics to be discovered by the students. These may definitely gear up the students' orientation for doing everything possible for them to develop and acquire the values in mathematics which are the skills in mathematics.

Validation Theory

SMaV Scale theoretical framework must be rooted in a particular theory through the testing of the validity of the theory, as revealed by USC(2022). Validation is one of the processes of scale development (DeVellis, 2012). So, validation theory is highly important for this study. Some Validation theories are classical test theory (CTT), generalisability (G) theory and item response theory (IRT). Generalisability (G) theory was originally developed by Lee J. Cronbach and his associates. Fredric Lord and other psychometricians developed IRT in the 1950s and 1960s, to overcome classical test theory limitations and have varieties of mathematical models (Zanon et al. 2016). This is supported by Kreiter & Zaidi, (2020) by declaring that G theory is used as a statistical framework for modelling and analysing measurements like direct observations or ratings. It also has ability to estimate reliability (precision) of measures and provide validity evidence. That is, G theory provides solutions to two issues: the issues of dependability and degree of consensus (Kyriakides, et al., 2010; Brennan, 2010). In generalisability, a sample will be representing the population of the Nigerian students so that the results of the study may be generalisable. There are two major types of generalisability theory. These are, univariate generalisability theory and multivariate generalisability theory (Brennan, 2010).

The three theories: the Value Theory, Value Orientation Theory and G theory from the Validation Theories are all applicable to this study. Value theory is applicable to this study in order to answer the question that Value theory asks on how and why people value something (Hitlin & Piliavin, 2004). Value orientation theory is also applicable to discover the orientations or beliefs upon which Mathematics students build their value for Mathematics in a way for them to be valuable in the future (O'Connell, 2015). For validation of the constructed items, Generalisability Theory is relevant. Considering the comprehensibility of the construct(s) of interest (Mathematics value) and the scale's validation establishment (reliability, validity and usability) a Value Scale Development (VSD) Theory can be derived from the three theories (Figure 1).

Validation of the Value Scale Development Theory (VSDT)

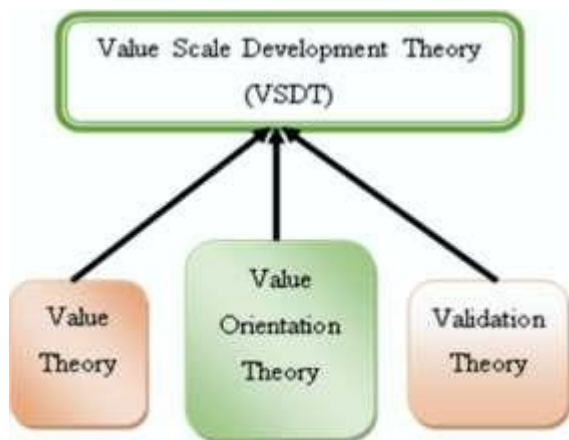


Figure 1: The Proposed Value Scale Development (VSD) Theory.

Source: Isaac-Oloniyo, 2022.

The VSD theory states that the development (that involves the construction and validation) of items from the components of the endogenous variables can produce a generalisable measurement tool for the construct of interest. For instance, for the SMaV Scale development, mathematics value and value orientation are the endogenous variables through which items were constructed and validated. Ninety-eight (98) items were constructed from the seven components of the skills that students can acquire in learning mathematics. The skills are the values or what students can find to be useful to them in learning mathematics. Such skills formed the components from which the items were constructed. The skills (components) are the Basic Skills, Thinking Skills, Reasoning Skills, Intelligence Skills, Emotional Skills, Problem-solving Skills and Time-Management Skills. The constructed items were subjected to validation processes to discover their psychometric properties.

Methodology

Research Design

Exploratory sequential mixed-methods design for scale development was adopted (Falaye, 2018).

Variables of Study

For this study, the dependent variable was value

scale development (VSD) theory. The independent variable was the student mathematics value (SMaV) scale development.

Population, Sampling Procedure and Sample

For the quantitative aspect of the study, the target population for this study was all the co-educational Post-basic institutions in the South-West geopolitical zone of Nigeria. Multi-stage sampling technique was used to select the twenty-four (24) selected schools from the three senatorial districts in each of the two selected States of the selected geopolitical zone. To meet the recommendation that at least 30 subjects per group must be in an intact class as cited in (Keter, Barchok & Ng'eno 2014) purposive sampling technique was used to select the twenty-four qualified schools for this study. The total number of students used in the study was one thousand and sixty-seven (1,067) students.

Instruments of Study

The two instruments used to gather data for the study are:

- Mathematics Stakeholders' Interview Guide (MSIG)
- SMaV scale Questionnaire

Results

Research Question 1: Is value scale development (VSD) theory able to explain the construct of students' mathematics value scale?

Answer to Research Question 1:

To answer the research question, exploratory sequential mixed-methods design for scale development was adopted. This began with qualitative exploration of the construct of interest, which is mathematics value. Inductive approach of the scale development was adopted for the exploratory aspects. This involved pre-instrument development stage. A qualitative research method with phenomenological theory design was used for the study. Six open-ended item interview guide was used for the exploratory study of the development of students' Mathematics value and students' Mathematics value orientation scales. The researcher prepared a Mathematics Stakeholders' Interview Guide (MSIG). The stakeholders are the Mathematics teachers,

students' parents and experts in the field of Mathematics (the University lecturers) and the Mathematics students of demographical similarities with those that would be finally involved for data collection. Then, items' formation components for Mathematics Values were explored by interviewing the stakeholders on their views and orientation towards Mathematics.

The interview involved fourteen respondents where two were lecturers from two universities, two were teachers of post basic institutions who also had children in the institutions and ten students from four different post-basic institutions. Atlas.ti 8 software package was used to analyse the interview responses. The stakeholders' were interviewed on their orientation for mathematics. Some of their responses in Figure 2 are that, their orientation for mathematics was as a result of their desire to achieve life-goals, to experience improvement, to gain knowledge and be able to successfully perform the required day-to-day activities. The stakeholders' were also interviewed on their means of learning Mathematics. Their responses in Figure 3 revealed that there are different means by which students learn mathematics. Some of these are through motivation, passion, focus, practices and love for the subject. All the indices (Figures 2 and 3) discovered from the inductive assisted the construction of SMaV Scale.

Stakeholders' Orientation towards Mathematics



Figure 2: Stakeholders' Orientation towards Mathematics

Stakeholders' Means of Learning Mathematics

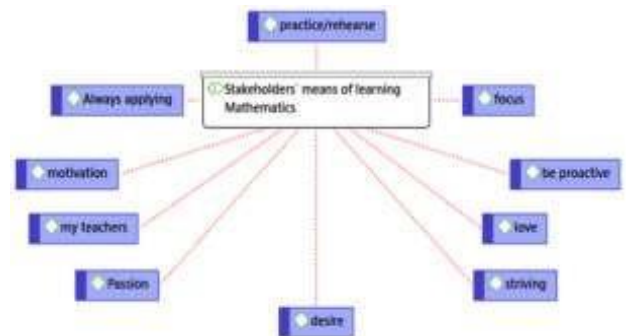


Figure 3: Stakeholders' Means of Learning Mathematics

Research Question 2: Is there any good-fit existing between the proposed (VSD) theory and the SMaV Scale observed data?

Answer to Research Question 2:

The three phases of SMaV Scale development are the item generation, item selection and item validation. Item generation involved the construction of 98 items from which 27 items were selected and items were validated by testing for the reliability and validity of the selected items using R studio software packages. The results of the analyses of the data collected showed that all the selected 27 items are valid: The Mathematics Value items' RMSEA = 0.032, this is < 0.05; RMSR is 0.02 which is close to 0; and Tucker Lewis Index (TLI) is 0.974 that is > 0.9. Also, the Value Orientation items' RMSEA = 0.044, this is ≤ 0.05; RMSR is 0.02 which is close to 0; and Tucker Lewis Index (TLI) is 0.958, that is > 0.9. Relatively speaking, good-fit exists between proposed theory and the SMaV Scale observed data (Hu & Bentler, 2009).

Conclusion: Value scale development (VSD) theory was developed and validated. It was then proposed and used as a theory for the development of the student mathematics value scale. The study revealed that the theory is an appropriate one for SMaV scale development. Hence, the proposed value scale development (VSD) theory had been found to be valid for (SMaV) Scale development.

Recommendation: Since the proposed value scale development (VSD) theory is a single valid theory that can be used as theoretical framework

for the development of (SMaV) Scale, it can be appropriately used for development of scales in other areas of disciplines, by any researcher expecting accurate outcome in any related studies. It is hereby recommended that researchers can adopt VSD theory for use in other future related studies.

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