Creating attitude scale for secondary school students in Papua New Guinea

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Abstract

Attitude is significant for students' mathematics learning at schools. Negative attitude towards mathematics among students in Papua New Guinea (PNG) is a concern for schools. The present status of attitude among students can be diagnosed through survey questionnaires. Using such a questionnaire is a successful way in measuring attitude in secondary students studying mathematics. The purpose of the present study is to examine the validity and reliability of attitude scale questionnaire using the Rasch model (Partial Credit Model) for the instruments to be used in Papua New Guinea and other Pacific Island Nations. The instrument consists of 20 survey questions, these are adapted from Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) studies because there are no specific items developed in PNG context to measure attitude scale as a single factor. These questions are validated using ACER ConQuest 4.0 software. The item separation index indicates good variability of the items and the items functioned well. All infit measures of the attitude scale questions satisfy the Rasch model's criteria except one item that does not conform to the requirements of Rasch measurement model.

Keywords: Mathematics, attitude, Rasch model, validity and reliability

Introduction

Attitude has been widely investigated in educational settings in recent studies. Negative attitude among students in learning has been a challenge for teachers. This is because positive attitude assists students to maintain interest and engage in mathematics activities. The lack of positive attitude among students results in poor mathematics performance, and consequently leads to declining mathematics results each year, limiting students to progress in their career pathways. This is evident from the reports that national mathematics achievement levels have declined in the past decade and therefore need close scrutiny (PNG NDOE, 2004; PNG NDOE, 2016; PNG DHERST, 2006a). This viewpoint is based on the annual Grade 10 and 12 students' mathematics national examinations results. Consequently, few students graduating from Grade 12 are able to enroll in universities to undertake mathematics related programs such as engineering and medicine. Simultaneously, there is a significant number of Grade 10 students who do not have a chance to continue to Grade 11 and are therefore forced out of the education system (Joskin, 2013; Le Fanu & Kelep-Malpo, 2015; Rena, 2011). The decline in students' mathematics performance may be due to different contextual factors affecting their results. This decline in mathematics results is indeed a great concern for the PNG government, parents, teachers and all those involved in the young adults' education (PNG NDOE, 2006a; 2006b and PNG NDOE, 2009). This state of affair has increased interest for mathematics teachers, researchers, and policy makers in understanding why students have negative attitude towards mathematics and consequently influence their mathematics performance. There are issues around how negative attitude affects the students' learning processes and the students' efforts to learn mathematics that affect the mathematics results. To clarify these issues, it is important to examine how attitude affect learners, and what means to measure attitude scale are needed.

As a result, a survey questionnaire has been developed to investigate students' attitude. The most relevant for this purpose of measuring attitude scale, twenty questions were adopted and developed from two international studies; Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA). These two studies define attitude as like, value and self-belief (Eklöf 2007, PISA 2016, Martin, Mullis et al. 2017). These two international studies (TIMSS and PISA) questions are adopted for the present study because no attitude scale has been developed in the PNG context until now and there is a need to establish one. The 20 questions are validated in the PNG context to determine their practical relevance in the context for the items to be used in future studies.

Literature review

In mathematics education literature, there has been much debate over the definition of *attitude*. The multidimensional nature of the concept has led to multiple definitions. Kiwanuka et al. (2017, p. 3) define *attitude* as "a disposition towards an aspect of mathematics that has been acquired by an individual through his or her beliefs and experiences, but which could be changed". A recent study by Yavuz Mumcu and Cansız Aktaş (2020, p. 5) refers to *attitude* as "an individual's tendency to have a positive or negative judgment of a sign, an object, or an individual around him/her". However, in the context of this study, attitude is defined as a "liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (Neale, 1969, p. 632). Despite the ambiguity in the definition of attitude from other researchers, over the last 25 years there have been a large number of studies that document the development of students' attitudes (Farooq & Shah, 2008; Kiwanuka et al., 2017).

Attitudes towards mathematics are the extent to which learners hold positive or negative feelings towards mathematics and their perception of its relevance, value and difficulty (Farooq & Shah, 2008; Kiwanuka, Van Damme, Anumendem, Van Den Noortgate, & Namusisi, 2015; Tok, 2015). Several studies have also shown a correlation between students' attitude towards mathematics and their achievements in the subject (Chen et al., 2018; Kiwanuka et al., 2017; Yavuz Mumcu & Cansız Aktaş, 2020). This relationship is highlighted in a study by Benken, Ramirez, Li, and Wetendorf (2015), which concludes that attitude toward mathematics is one of the most significant factors influencing participation in the subject. For instance, a study by Aytekin and Isiksal-Bostan (2019) in Turkey has shown that, when compared with their female counterparts, male students tend to have more negative attitudes towards the use of technology in mathematics lessons. This kind of difference in attitude tends to continuously become more negative as students move from primary to secondary school. Pitsia, Biggart, and Karakolidis (2017) highlight that many students fail to excel in mathematics due to an inadequacy of self-belief that can ensure the development of a positive attitude. Consequently, student performance in mathematics drops as they view and believe that mathematics is an exceptionally difficult and boring subject (Iqbal, Mirza, & Shams, 2017; Kiss, 2018; Soni & Kumari, 2017). Another study by Shin, Slater, and Ortiz (2017) on reading and mathematics in Korea and the USA highlights that this kind of negative attitude is a hindrance to students' achieving better results. The factor which has the biggest impact on mathematics performance is negative student attitudes. From the author's teaching experience and literature, it is believed that students with positive attitude in a particular subject perform well and obtain better academic results.

There are several elements related to the formation and development of a student's attitude towards mathematics. In studies by Yavuz Mumcu and Cansız Aktaş (2020, p. 4) and Kiwanuka et al. (2015, pp. 1-2) attitude is discussed in the context of three components: *cognitive, affective* and *behavioral*. These three components also comprise the attitude construct in the context of this study. The affective component refers to the liking-disliking aspect of attitude that changes from student to student and cannot be explained by facts (Yavuz Mumcu & Cansız Aktaş, 2020, p. 5). The cognitive component relates to students' knowledge and possession of confidence in their ability to learn and perform well in mathematics tasks (Kiwanuka et al., 2017; Yavuz Mumcu & Cansız Aktaş, 2020). The behavioral component is associated with the value that individual students place on the usefulness of mathematics, which enables him/her to understand the importance of mathematics for everyday use and later in life (Kiwanuka et al., 2017). Together, these three dimensions comprising the attitude construct interact and manifest themselves in the establishment of positive student attitudes in mathematics.

As mentioned earlier, in this paper, combined survey questions for the attitude scale from the TIMSS and PISA are used to acquire information from participants in an efficient way. The survey questionnaires/items in this study are therefore mostly adopted with modifications. The scale attitude (unobserved variable) was partly derived from the theoretical framework (see Figure 1.1 in Appendix B p.16) that was used for the researcher's PhD study to determine the student outcome (mathematics results). Even though these questions were validated by experts, they are verified and validated again in the context of Papua New Guinea where the survey was carried out. The application of the items in the research context is taken into consideration for the suitability and usefulness of the instruments. As a result, items that are insignificant are abandoned in the final instruments. These new instruments (items) are likely to be valid in other countries and could be used accordingly in their context.

Aim and Research Question

This study aims:

a) to validate the attitude scale by examining the validity of the adopted PISA and TIMSS survey questionnaire in PNG context
b) to measure the appropriateness of the survey questionnaire using the Rasch model.

The guiding research question for this study is:

How valid and reliable is the survey questionnaire for attitude scale employed in PNG schools?

Methodology

This section of the paper discusses the methods used to collect and analyse the attitude scale questionnaire data.

Prior to the administration of this study, it was necessary to obtain ethical research approval from the University of Adelaide's Human Research and Ethics Committee (UAHREC). The UAHREC granted approval for this study to proceed on 14 July 2017 (Ethics Approval No H-2017-133). The committee's approval was granted on five conditions to which the researcher must conform: 1) every participant be provided with an information sheet about the study; 2) every participant must read, sign and return the consent form to the researcher to participate in the study; 3) consent from parents/guardians was to be obtained for participants below the age of 18 years; 4) the identity of every participant was to be kept confidential when conducting survey questionnaires and; 5) participation was voluntary and participants were free to discontinue at any time. All conditions have been met in relation to this study.

Research methods and sampling procedure

This study applies a stratified random sampling technique (Creswell 2008, Joncas and Foy 2011). This technique allowed the researcher to arrange and divide the population of the schools in Port Moresby, PNG (target population) into groups, or strata, which shared common characteristics. For instance, schools are arranged within school type (private, government, church) in each suburb and the participants' gender group. The type of schools selected for the study are private, government and Catholic schools. This technique ensures balanced representation of each school and gender in the selected sample for Port Moresby, PNG (Joncas and Foy 2011). The Grade 10 and 12 participants did a 40 questions mathematics test, respectively in 1 hour. The data was collected from October to November of 2017.

The primary data collected was from 729 students; i.e. 354 Grade 10 and 375 Grade 12 students, respectively from 15 different secondary schools in Port Moresby, PNG. The genders in both were in proportion to males and females in each school in Port Moresby. The 15 schools selected in Port Moresby were based purely on the amount of research work that was scheduled and the availability of the schools.

Instrument

The instrument used to collect data in this study is survey questionnaires for student participants. The survey questionnaires for students were designed to gauge students' attitude towards mathematics. Attitude scale items from the TIMSS 2015 and PISA 2012 studies are adopted and used in this study. This approach was taken due to unavailability of attitude scale items in PNG context. These two international studies provided

20 items for the attitude scale (see Table 1.1 Appendix A). Grade 10 and Grade 12 students are selected to participate in this study because they sit for PNG national examination each year. The results of this examination continues to decline over the years and many students are unable to do Grade 11 and go to universities and colleges, respectively. The PISA and TIMSS survey questionnaires are used because these two international studies measured students' attitude towards mathematics. It is evident from reports of participating countries that the attitude can have an impact on the mathematics results of students. PNG did not participate in these international study, therefore, these survey questionnaires are employed in the PNG context with the expectation that they can measure the students' attitude and can assist in developing its own attitude scale. The scale consists of 19 positively-worded items and one negatively-worded item, using a four-point Likert-type scale: "strongly agree", "agree", "disagree" and "strongly disagree" (Penfield, Myers et al. 2008, Thomas, Schmidt et al. 2016). The four-point Likert-type scale was employed to get specific responses from the participants.

The attitude scale was adapted, modified, and developed from the existing instruments, with literature used as a guide. Adaptation, modification and development of the scales required certain steps to ensure that the participants responded to the items with clarity within the time frame. The researcher provided a draft of the survey items to an experienced teacher in PNG to examine and make suggestions and comments based on the context of the research site. Further to this, the items were also provided to PhD candidates from the School of Education (The University of Adelaide). This procedure ensured that there was clear direction with clarity in language, format and structure, brevity, and applicability to student and teacher respondents. This trial was timed in order to evaluate any difficulties that may arise when students in PNG are responding to the items. The two students' responses were incomplete, and so the researcher increased the timing and adjusted the content of the questionnaires, accordingly.

In order to further explore attitude scale, the study included 20 attitude items in the student questionnaire. These items were developed from already well-known scales described by the TIMSS and PISA studies. Attitude scale's 20 items were focused on the attitude scale as a single factor model. The attitude scale items were labelled Attd01-Attd20 for data analysis purposes as shown in Table 1.1 (see Appendix A). Item responses were coded 1,2,3 and 4, corresponding to the categories "strongly disagree"," disagree"," agree" and "strongly agree", respectively. Moreover, items responses that were missing or omitted were coded "9", which is an arbitrary value assigned for recognition with the statistical software as a non-response (Blackwell, Honaker et al. 2017). In order to keep scoring consistency, the single negatively-coded item was reverse scored (Crenshaw, Christensen et al. 2017) . The items were recoded so that the higher scale scores reflected more positive attitude. Attitude scale used in the PNG study consists of 20 items measuring attitude.

The 20 items adopted from PISA and TIMSS studies are labelled accordingly as shown in Table 1.1 (Appendix A). Item Attd27 'I like studying for my mathematics class outside of school.' attempts to measure students approach to mathematics outside of school. Item Attd28 'I am studying mathematics because I like to learn new things' aims to find out how students learn new approaches by liking mathematics. Moreover, Item Attd29 'I look forward to my mathematics lessons.' measures the students' attentiveness to mathematics. Items Attd30 'I enjoy thinking about the world in terms of mathematics relationships' and Attd31 'I do mathematics because I enjoy it' seek to measure the student's enjoyment in learning mathematics. Furthermore, item Attd32 'I enjoy figuring out challenging mathematics' attempts to see students' attitude with difficult mathematics problems. Item Attd33 'Learning mathematics is important because it stimulates my thinking' and Item Attd34 'Learning mathematics is a worthwhile exercise' seeks to measure the significance of mathematics in the students' perceptions.

In addition, items Attd35 'I am curious when I am learning mathematics' and Attd36 'When I do mathematics problems, it completely gets my attention' attempt to measure the students' interest in doing mathematics. Item Attd37 'I get a sense of satisfaction when I solve mathematics problems' and Item Attd38 'Mathematics is an important subject for me because I can use in my daily life' measure the students' general feeling towards learning mathematics. The item Attd39 'Sometimes the mathematics course material is too hard' highlights the students' negative perception towards mathematics. Furthermore, Attd40 'I feel confident in mathematics class' and item Attd41 'I want to study mathematics regularly' measure the students' confidence level in mathematics. Item Attd42 'Making an effort in mathematics is worth it because it will help me in the work that I want to do later on' attempts to measure the value of mathematics in the society. Moreover, Item Attd43 'I want to do well in mathematics' and Item Attd44 'I want to try harder in mathematics' measure students' different perceptions in mathematics. Item Attd45 'I do badly in mathematics whether or not I study for my examinations' emphasize the students' attitude towards mathematics. Finally, item Attd46 'I am very good at solving mathematics problems' measures students' ability in mathematics. These items descriptions measure the single attitude scale in this study.

Data analysis criteria

The Partial Credit model is used to analyze the data. The item difficulty level and person ability of the motivation scale are measured on the same continuum using ConQuest 4.0 software. The Rasch analysis consist of several analytical steps and criteria to determine the validity of each of the motivation scale item. The first criterion is unidimensionality. One of the basic assumptions of the Rasch model is unidimensionality, which refers to the existence of a primary construct (dimension) that accounts for variance in sample response. This indicates that the items in a test measure one single latent ability. For instance, a rectangular solid has many attributes such as length, height, weight, volume and density. The focus is only one of these attributes for meaningful estimation of the objects under scrutiny (Bond and Fox 2015).

Moreover, evaluation of fit indices for all items and persons based on Infit and Outfit statistics allows us to determine the unidimensionality of the instrument. In the standardized mean square (ZEMP) of fit statistics, the mean square value is transformed, with sample size to produce a distribution such as *t*. The infit MNSQ statistics used in this paper is used for item fit. The acceptable values of the MNQS are placed in the interval between 0.7 and 1.30 where 1 is the ideal (Tejada, Luque et al. 2011, Bond and Fox 2015). There are no hard rules on cut-off scores and Skrodal (2010) suggests an infit MNSQ range of 0.6-1.4 as reasonable for data collected from a survey and this criterion is employed in this study. In ZEMP (*t* value), 0 means that the model satisfactorily predict the observed data, and an interval between -2 and 2 specify acceptable fit (Tejada, Luque et al. 2011, Bond and Fox 2015).

The second criterion used to judge the instrument is the separation index and separation-reliability index: The separation index indicates how well the scale separates items (i.e., item separation), and individuals (i.e., person separation)(Wright and Stone 1999). The minimum value for the separation index is 1.0. A high separation index indicates adequate discrimination for either an item or person. Item separation index can be used as an index of construct validity and the person separation index can be used as an index representing criterion validity (Wright and Stone 1999, Bond, Fox et al. 2007). Separation-reliability denotes the feasibility of replicating item or person placements within measurement error for another sample. A separation-reliability close to 1.0 indicates a high degree of confidence for the placement of either an item or person (Bond, Fox et al. 2007, Bond, Fox et al. 2007).

The third technique is to check for the discrimination index (point biserial) to judge whether each of the motivation scale items are discriminating with the higher and lower ability respondents.

Rasch analysis results

The attitude scale in this study that is applied to survey students in Port Moresby, PNG, was adapted to a different context than the items' original contexts in PISA and TIMSS assessment. Hence, the utility of the items is checked using the Rasch model with ConQuest 4.0, software. The partial credit model (PCM) assumes that the distance between the thresholds of the items is different (Eggert and Bögeholz 2010). Hence, in this study PCM is employed to analyse the items for the attitude scale response categories because it is a parsimonious model and minimises the mean square error. This procedure is useful for surveys such as the attitude scale items, where they are not marked for correct or incorrect answers (Penfield, Myers et al. 2008). Survey results from the analysis, shown in Table 1.1, demonstrate that data fits the model well which indicates that PCM is a more parsimonious model (Wang and Wu 2011). The 20 items in the attitude scale are subject to item analysis using the PCM. This is carried out to test the unidimensionality of the 20 items measuring the construct (attitude). This involves examining each item's fit statistics using statistical criteria and procedures.

The separation reliability index of the item is the analogue to the Cronbach alpha (measure of scale reliability). In this case, sample reliability was 0.99 and is considered to be good. This indicates that the items are discriminating between low and high-ability respondents showing minimal measurement error. Separability focuses on whether the scale is defined by the distinct hierarchy of items.

Table 1.2 shows that all items fit the model with the INFIT MNSQ criteria of 0.6 to 1.40 (Bond, Fox et al. 2007, Bond and Fox 2015). However, the t- values of Attd27 ('I like studying for my mathematics class outside of school') is 4.0 and Attd31 ('I do mathematics because I enjoy it') is -2.9, which are not within the acceptable fit criteria of -2 to 2, and as such was non-significant for the model. Further, the item thresholds are ordered and had a low discrimination index of 0.41. The researcher decided to delete the item due to violation of the Rasch model requirements. The results of the final run of analysis shown in Table 1.2 indicates that all the statistical fits of the items meet Rasch model requirements (Wu and Adams 2007, Wu, Tam et al. 2016).

Moreover, Table 1.2 demonstrates the different range of item endorsement of the 20 calibrated survey items from 0.86 to 1.22 logits and is connected to a standard error of 0.04 to 0.09 logits. These items show difficulty index measures, identify the different response level of an item and classify the level of an item as easy, moderate, or hard to endorse (Zainuri, Asshaari et al. 2016). Furthermore, the results of the point biserial index (r_{pb}) of the items in Table 1.2 ranges from 0.41 to 0.69. This result shows that the items are discriminating and differentiating among respondents, and it implies that the items indicate a relationship between the respondents' performance on the given item (correct or incorrect) and the respondents' score on the overall test (Wu and Adams 2007, Wu, Tam et al. 2016, Quaigrain and Arhin 2017).

Table 1.2 Analysis outcome of the Rasch measurement model (n=729)

			Weighted Fit						
Item(s)	Estimate	Error	MNSQ	CI	t	Pt Bis	Item Delta		
Attd27	0.42	0.04	1.22	(0.90,1.10)	4.0	0.46	-1.01	0.04	2.1
Attd28	-0.46	0.04	0.96	(0.90,1.10)	-0.7	0.55	-1.99	-0.78	1.55
Attd29	-0.66	0.04	0.96	(0.89,1.11)	-0.8	0.57	-1.75	-1.41	1.43
Attd30	0.63	0.04	0.96	(0.90,1.10)	-0.9	0.59	-1.25	0.53	2.38
Attd31	-0.03	0.04	0.86	(0.90,1.10)	-2.9	0.67	-1.75	-0.01	1.67
Attd32	0.09*	0.09	0.99	(0.90,1.10)	-0.2	0.60	-1.18	-0.09	1.52
Attd33	-0.35	0.04	0.95	(0.89,1.11)	-0.9	0.53	-1.34	-0.84	1.18
Attd34	0.38	0.04	1.05	(0.89,1.11)	0.8	0.42	-0.50	-0.44	2.02
Attd35	0.41	0.04	1.08	(0.90,1.10)	1.5	0.41	-0.98	0.14	1.97
Attd36	-0.07	0.04	0.98	(0.89,1.11)	-0.3	0.50	-1.12	-0.38	1.32
Attd37	-0.27	0.04	1.00	(0.86,1.14)	0.1	0.41	-0.59	-0.43	0.34

Attd38	0.12*	0.09	0.97	(0.89,1.11)	-0.6	0.51	-1.08	-0.60	1.33
Attd41	0.38	0.04	1.06	(0.90,1.10)	1.3	0.69	1.21	2.18	5.37
Attd42	-1.38	0.04	1.07	(0.88,1.12)	1.1	0.56	-2.83	-1.22	2.15
Attd46	0.99*	0.06	0.97	(0.90,1.10)	-0.6	0.61	-1.07	0.24	1.96

Separation Reliability = 0.995, Chi=square test of parameter equality=2142.93,df =12, Sig Level =0.000

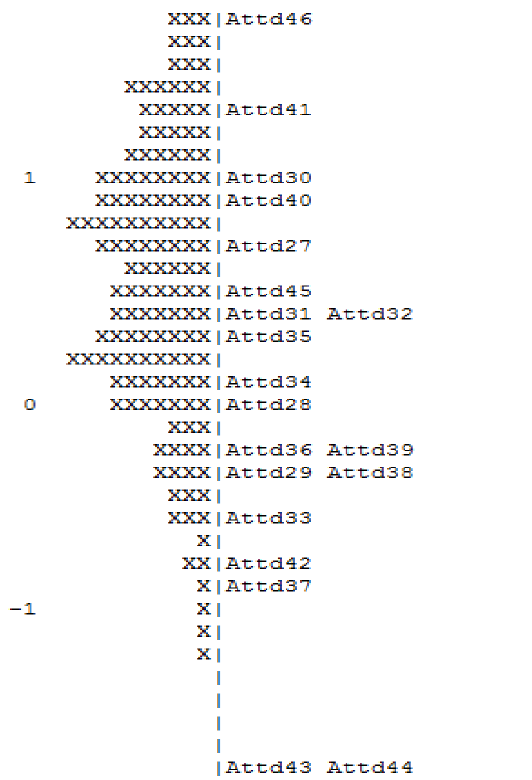

Figure 1.1 Wright-map of the 20 items of motivation scale as a single level factor

Figure 1.1 contains an examination of the Wright-map, showing most of the items located around the mean (zero logits), whereas the majority of the respondents, ability levels are above the average. This indicates that most of the respondents have positive attitude and the items are easy for them to response. These items are easy because they are located below logit -1 and respondents with both low and high ability level answered the items correctly. Majority of the respondents have greater than 50% chance of endorsing items with difficulty level below their ability, and vice versa.

Discussion and conclusion

Construct validity of the attitude scale questionnaire

The main purpose of this study is to provide more information about improving the questionnaires of the attitude scale. This is because positive attitude leads to greater aspiration in mathematics and science related fields. As such, as shown in Table 1.2 that all the items satisfy the Rasch model's statistical criteria and threatens the validity of the attitude scale and is supporting the unidimensionality structure. This means the item violates the Rasch model's criterion and there is consistency in interpreting the underlying measure. The items are measuring the same latent construct in the survey and all the model fits the data well.

The person-map in Figure 1.1 (from left to right) is employed to assess the attitude scale on which both item and the respondents are calibrated on a logit scale. In Figure 1.1, the numbers on the far left are from -1 to around +1. The relative item difficulty is plotted on the right side of the scale and attitude estimates on the left side of the same scale on the person-map. The respondents at the top of the map represent positive attitude students to endorse the questions while the person at the bottom demonstrates negative attitude to endorse. Similarly, the items on the top are more difficult to endorse while the ones at the bottom are relatively easier to endorse (Bond, Fox et al. 2007, Bond and Fox 2015). The logit zero on the person-map is set at the average item difficulty and overall, the mean attitude of students is higher than the average difficulty. The positive logits values represent the items that demand positive attitude of students. The result in Figure 1.1 indicate that most of the items less meet the need of positive attitude participants. In addition, two items in the person-map does not correspond to the respondents' endorsement motivation and are very easy (Attd43 and Attd44). Consequently, respondents have more than 50 percent probability of endorsing the items accordingly (Boone, Townsend et al. 2011). While the Rasch analysis shows that attitude, parameters are higher and most of the items had slightly inappropriate coverage. The results of the Rasch model thus demonstrates room for improvement of the motivation scale questionnaires.

The study contributes to the methodological significance through reliability and validity of a mathematics attitude scale using two psychometric approaches (unidirectionality and separation-reliability index) as a way of comparison. This research study involves questionnaires that examine attitude scale. The survey instruments for scales were validated and calibrated to obtain reliable data. This validation of the construct questionnaires was carried out through the Rasch Model, using ConQuest 4.0. The findings of this study reveal that researchers can produce different results from the construct validation and that depends on the selection of analysis methods employed. This is because using a rigorous method such as Rasch analysis for measuring attitude scale has advantages and disadvantages of the psychometric properties.

The use of attitude scale questionnaire in research and instruction

The researchers, teachers and other educators will be able to readily assess students' attitude towards mathematics if the attitude scale is further improved as stated above. In terms of research, these attitude scale questionnaires can be used to find the relationship between other educational variables through statistical tests. For instance, the student's positive attitude to learn mathematics differs from their career goals, parent involvement on their learning and prior knowledge in mathematics. Furthermore, the questionnaire can also be used with other research methods such as qualitative methods using interviews and group discussions, for comprehensive insight into their attitude in learning mathematics. The questionnaires can be used as an instructional tool to find reasons for the negative attitude among students that can assist teachers to adjust to different teaching styles to develop a conducive learning environment that promotes positive attitude among students. It also assists teachers to identify students with negative attitude and foster positive teaching relationship with students. Moreover, the Principals/head teachers and faculty heads could track students with negative attitude in mathematics who are more likely to experience difficulty in completing their studies (degree programs) at various institutions. This process can assist institutions to set strategies to improve students' attitude by providing alternative programs for students at risk and by reorganizing schools.

The students' scores on the attitude scale produces the logit scores with the Rasch analysis rather than raw scores because all items have different response levels and thus different items do not contribute equally to the attitude scale's total score. In addition, the items of the attitude scale instrument are Likert-type scales, which could be regarded as an ordinal scale. The ordinal scale does not have same distance between a score of 1 (Strongly disagree) and 2 (Disagree), and a score of 3 (Agree) and 4 (Strongly agree); which is not allowed to sum score of all item responses. The logit scores are generated through consideration of each item difficulty and the transformation of ordinal scales to interval scales.

Apart from other attitude instruments, this study used the instruments (survey items) from international studies such as TIMSS and PISA. These items in these two studies are adopted by most studies to measure attitude scale due to the application of rigorous statistical validation methods. The findings from TIMSS and PISA studies indicate that attitude has a significant effect on the students' mathematics results. However, in this study the adopted instruments from TIMSS and PISA are employed and validated in the context of Papua New Guinea to create attitude questionnaires for researchers in the Pacific Island nations.

Student attitude is key to academic success so efforts to make better policies for practices needs attention to increase student attitude at schools. The instrument of attitude scale validated in this study informs the status of student attitude. It further explains the association between performance and attitude status to provide an indication of the extent to which the education policies should target students with negative attitude. This study should inform the teachers, educators, and principals/head teachers and policymakers who are interested in improving student to poster positive attitude.

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Appendix A

Table 1.1 Summary of items in the attitude scale used in the study

Item code	Item Text	Item adopted from/Item No
Attd27	I like studying for my mathematics class outside of school.	TIMMS (20d)
Attd28	I am studying mathematics because I like to learn new things	TIMSS (20g)
Attd29	I look forward to my mathematics lessons.	PISA (31c)
Attd30	I enjoy thinking about the world in terms of mathematics relationships	TIMSS (20l)
Attd31	I do mathematics because I enjoy it.	PISA (31d)
Attd32	I enjoy figuring out challenging mathematics.	TIMSS (20h)
Attd33	Learning mathematics is important because it stimulates my thinking.	TIMSS (21a)
Attd34	Learning mathematics is a worthwhile exercise	PISA (31e)
Attd35	I am curious when I am learning mathematics.	PISA (36h)
Attd36	When I do mathematics problems, it completely gets my attention.	TIMSS (20a)
Attd37	I get a sense of satisfaction when I solve mathematics problems.	TIMSS (20b)
Attd38	Mathematics is an important subject for me because I can use in my daily life	PISA (31g)
Attd39	Sometimes the mathematics course material is too hard.	PISA (35d)
Attd40	I feel confident in mathematics class.	PISA (31c)
Attd41	I want to study mathematics regularly.	PISA (36a)
Attd42	Making an effort in mathematics is worth it because it will help me in the work that I want to do later on.	TIMSS (21i)
Attd43	I want to do well in mathematics.	TIMSS (21b)
Attd44	I want to try harder in mathematics.	TIMSS (21e)
Attd45	I do badly in mathematics whether or not I study for my examinations	PISA (34f)
Attd46	I am very good at solving mathematics problems.	PISA (35a)

Appendix B.

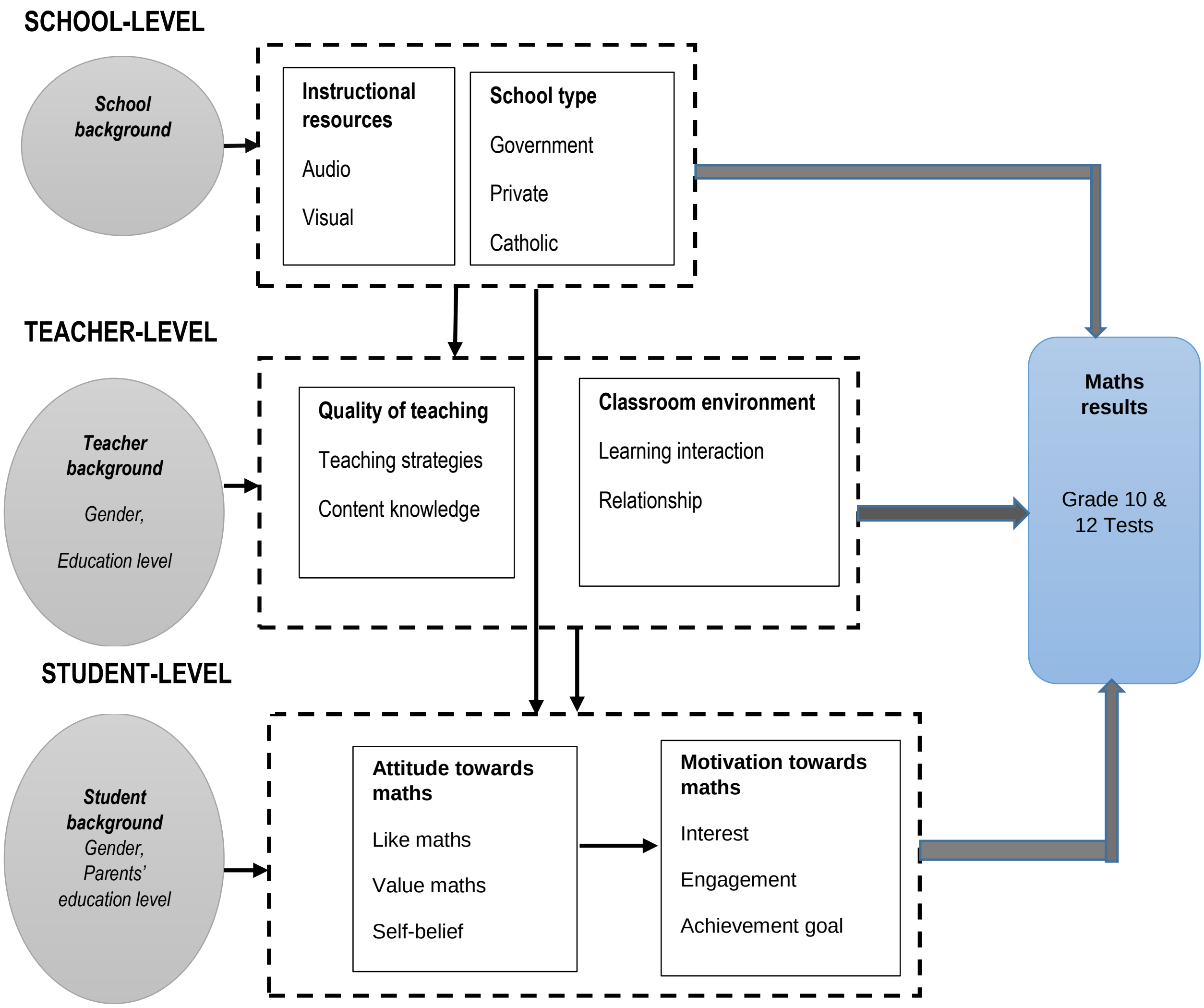

Figure 1.1 Proposed theoretical framework for the study (OECD, 2004 & OECD, 2010)

About the author

Jerome Oko, PhD, is currently the Campus Administrator for Divine Word University (DWU) at Port Moresby Campus in Papua New Guinea. He obtained his Bachelors in Education-Technical degree from Don Bosco Technological Institute in Papua New Guinea. He received his Master and Doctoral degrees in Mathematics Education from the University of Adelaide, South Australia. His Research areas include Mathematics and Science Education. His research covers measurement and evaluation in Education. He mainly employs in his data analysis newer psychometric techniques such as Rasch model and multi-level modelling.

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