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Creating a motivation scale for secondary school students in Papua New Guinea

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Abstract

Motivation is important for students' mathematics learning at schools. Low levels of motivation among students in mathematics in Papua New Guinea (PNG) is a concern for schools. The present status of motivation can be diagnosed through survey questionnaires. The purpose of the present study is to examine the validity and reliability of a motivation scale questionnaire using the Rasch model (Partial Credit Model). The instrument consists of 20 survey questions that were 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 the PNG context to measure motivation scale as a single factor. These questionnaires 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 motivation scale questionnaires satisfy the Rasch model's criteria except one item that does not conform to the requirements of Rasch measurement model.

Introduction

Motivation has been widely investigated in educational settings in recent studies (Chamberlin et al., 2018; Alkaabi et al., 2017). The decline of motivation among students in learning has been a challenge for teachers (Yanay & Yanay, 2008; Zusho et al., 2003; Wijsman et al., 2019). This is because intrinsic motivation prompts students to maintain interest and engage in mathematics activities. Students' poor performance in mathematics is due to a lack of motivation. As a result, the students' mathematics results decline and limit their progress into their preferred career pathways. This is evident from the National Education Secretary in PNG stating that national mathematics achievement levels have declined in the past decade and therefore need scrutiny (PNGDOE, 2006a, 2006b, 2009). 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 young adults' education (PNGDOE, 2006a, 2006b, 2009). This state of affairs has increased interest for mathematics teachers, researchers, and policy makers in understanding the underlying decline in motivation as a factor to explain its crucial aspects associated with the poor mathematics performance. There are issues around how motivation influences 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 learners' motivation could be assessed and what means to measure motivation are needed.

As a result, a survey questionnaire has been developed to investigate students' motivation. The most relevant for this purpose of measuring motivation scale, 20 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 motivation as a form of engagement that is regulated and sparked by interest and to achieve a certain goal in the mathematical task (Eklöf, 2007; OECD, 2016; Martin et al., 2017). These two international studies (TIMSS and PISA) questions are adopted because no motivation 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

Motivation is a significantly important factor for academic learning and achievement. According to Gholami et al. (2020), motivation is an important contributor to student achievement. It is also one of the most important ingredients of success in mathematics (OECD, 2013, 2014). Greater motivation can drive individuals, especially those with less talent, to reach their goals (Tuomi, 2006; OECD, 2013). Motivated students are more likely to succeed and perform better than students who have talent alone, and are more capable of setting goals for themselves to stay focused on their mathematics studies (Ross, 2008; Hopfenbeck & Kjaernsli, 2016). The motivation to achieve goals leads students to pursue work they perceive to be valuable and prompts them to compete with others (Ross, 2008; Hopfenbeck & Kjaernsli, 2016). In other words, students' motivations influence their learning and performance on assessments of mathematics. For instance, findings from international large-scale assessments, such as IEA's Trends in International Mathematics and Science Study (TIMSS) reveal that there is correlational and experimental evidence for the association of motivation with achievement with reference to longitudinal and cross-cultural comparisons (Martin et al., 2011).

In the context of this study, motivation is defined as the promotion of engagement of students in mathematics learning activities, as similar to the TIMSS and PISA studies (Martin et al., 2011). Students with less motivation are less interested and are more likely to be disengaged in learning mathematics (Yu & Lee, 2020). Instead, students with greater motivation get actively involved in mathematics tasks with pleasure and satisfaction derived from their participation, due to their competency level in mathematics (Ryan & Deci, 2017, 2020). Motivation to experience stimulation takes place when students engage in an activity in order to experience stimulating sensations derived from one's engagement in the activity (Gottfried, 2019; Liu et al., 2020). Gottfried (2019) and Heyder et al. (2020) highlight that typical motivations include interest, enjoyment, fun, self-determination and self-growth. Recent studies believe that students that have these motivational factors are engaged in learning mathematics (Ryan & Deci, 2017; Heyder et al., 2020; Yu & Lee, 2020). Students with motivation tend to do better at school (Gherasim et al., 2013; OECD, 2013), they set goals to achieve in mathematics that lead them to be more involved and be engaged in their studies (Eklöf, 2007; Hopfenbeck & Kjaernsli, 2016). This in turn provides students with "higher autonomous and internalised achievement motivation with higher self-esteem, stronger cognitive awareness and greater efforts invested at mathematics" (OECD, 2017, p. 94). A study by the OECD (2013) highlights that motivated students are typically autonomous individuals who believe that they can learn in various positive ways to solve mathematical problems. Another OECD (2017) study proposes that this attitude stems from a student's sense of responsibility and obligation in their approach to learning mathematics.

Students' participation in learning reflects on behaviors of persistence, concentration, attention, asking questions and contributing in mathematics learning (Fredricks et al., 2004). According to OECD studies, engagement in mathematics enables students to be involved in active learning as it encourages them to think on the specific task (OECD, 2013, 2017). The role of engagement in mathematics learning is significant, and based around student-centred activities that support conceptual competences (Martin et al., 2011), and encourage active involvement in learning (Wilson, 2011; Martin et al., 2012). The OECD (2004) reports that increasing students' interest in the area of mathematics leads to higher test scores and student achievement in various contexts. A study by Cleary and Chen (2009) found a positive correlation between student interest, motivation, and better mathematics results. From these studies, it is clear that, when students are interested in their studies, they are more motivated, connected, and engaged in mathematical task (OECD, 2013; Nyman, 2017). The OECD (2013) recommend that specific strategies applied in mathematics teaching and learning can capture students' interest.

A synthesis of 12 empirical studies of the effects of examinee motivation on test performance by Wise and Demars (2005) discovered that the average difference between less motivated and highly motivated students was a 0.58 standard deviation. This indicates that motivation could have a significant influence on students' test scores. A cross-country study by Eklof et al. (2014) on the relationship and effort on the TIMSS Advanced mathematics test in 2008 in Sweden, Norway and Slovenia reveals that students in each country reported low motivation, but there was a significant relationship between reported effort and test performance. Furthermore, the OECD has also attempted to measure students' test motivation. For the second PISA cycle, in 2003, OECD developed and included a measurement of motivation, asking the 41 participating countries to include it in the booklets given to students (OECD, 2001). After the PISA 2003 cycle, the results showed overall that students across all participating countries answered they would have been more motivated to do the test if it had influenced their school marks (Butler & Adams, 2007). As it is evident from the literature review, there are mixed results from previous studies on motivation with some studies indicating that test motivation is related to higher performance, while other studies have not found such a relationship. What researchers have found is that females report higher levels of motivation to do their best while there tends to be a stronger relationship between high motivation and performance for males.

As mentioned earlier, in this paper, combined survey questions for the motivation scale from the TIMSS and PISA are used to acquire information on participants in an efficient way. The survey questionnaires/items in this study for motivation are therefore mostly adopted with modifications. The scale motivation (unobserved variable) was partly derived from the theoretical framework (see Appendix B) that was used for the researcher's PhD study to determine the student outcome (mathematics results). Even though these questionnaires 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 instrument (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 motivation scale by examining the validity of the adopted PISA and TIMSS survey questionnaire in the PNG context

(b) to measure the appropriateness of the survey questionnaires using the Rasch model.

The guiding research question for this study is: How valid and reliable is the survey questionnaire for motivation scale employed in PNG schools?

Methodology

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

Research methods and sampling procedure

This study applies a stratified random sampling technique (Creswell, 2008; Joncas & 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 in this 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 & Foy, 2011). The Grade 10 and 12 participants did a 40-question mathematics test in one hour. This technique allowed the researcher to arrange and divide the population of the schools in Port Moresby into groups, or strata, which shared common characteristics. For instance, schools were arranged within specific geographic regions, school type (private, government, church) in each region, and participants' gender group. This technique ensured a balanced representation of each school and gender in the selected sample (Joncas & Foy, 2011). The data was generated 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. The female-male gender distribution in both cohorts was approximately proportionate in each school. 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' motivation towards mathematics. Motivation scale items from the TIMSS 2015 and PISA 2012 studies are adopted and used in this study. This approach was taken due to the unavailability of motivation scale items in the PNG context. These two international studies mentioned above provided 20 items for the motivation scale (see Appendix A). As this paper aims to measure students' motivation, the motivation scale items are employed to collect data for Grade 10 and 12 students in Port Moresby. Grade 10 and Grade 12 students are selected in this study because they sit for PNG national examination each year. The results of these examinations continues to decline over the years and many students cannot do Grade 11 and go to universities and colleges, respectively. The PISA and TIMSS survey questionnaires are used because these two international studies measure students' motivation towards mathematics. Although PNG does not participate in the two aforementioned international studies, it is evident from reports of participating countries that the motivation can have an impact on the mathematics results of students. Therefore, these survey questionnaires are employed in the PNG context in the belief that they can measure the students' motivation and can assist in developing its own motivation 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 et al., 2008; Thomas et al., 2016). The four-point Likert-type scale was employed to get specific responses for the participants.

The motivation scale was adopted, modified, and developed from the existing instruments, with literature used as a guide. Adoption, 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, brevity, clear format and structure 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. 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 questionnaires were validated through Rasch analysis due to the informative and practical approach this statistical technique has to assess the questionnaires that addresses issues of construct validity in educational assessment.

In order to further explore motivation scale, the study included 20 motivation items in the student questionnaire. These items were developed from already well-known scales described by the TIMSS and PISA studies. The motivation scale's 20 items were focused on the motivation scale as a single factor model. The motivation scale items were labelled Mtvn07-Mtvn26 for data analysis purposes as shown in Appendix A. Item responses were coded 1, 2, 3 and 4, corresponding to the categories "strongly disagree"," disagree"," agree" and "strongly agree", respectively. Moreover, item 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 et al., 2017). In order to keep scoring consistency, the single negatively-coded item was reverse scored (Crenshaw et al., 2017). The items were recoded so that the higher scale scores reflected more positive motivation. Motivation scale used in the PNG study consists of 20 items measuring motivation.

The 20 items are adopted from PISA and TIMSS studies and are labelled accordingly as shown in Appendix A. Item Mtvn01 'I am prepared for my mathematics examinations' attempts to measure whether preparation in examinations has a motivation factor in learning mathematics. Item Mtvn02 'Jobs that require mathematics skills seem interesting to me' aims to find out how jobs that require mathematics skills motivates students to be involved actively in mathematics. Moreover, Item Mtvn03 'Learning mathematics will help me get ahead in the world' measures the perception of mathematics in the real world. Items Mtvn04 'It is important to do well in my mathematics class' and Mtvn05 'Doing well in mathematics will help me get into university/colleges' seeks to measure the student's motivation in learning mathematics. Furthermore, item Mtvn06 'Learning mathematics will give me more job opportunities' and Mtvn 07 'Learning mathematics is worthwhile for me because it will improve my career prospects' attempts to understand the students' motivation in learning mathematics regarding career and jobs in the future. The item Mtvn08 'I keep studying until I understand mathematics material' turns to measure how motivated students are in studying mathematics in order to understand the concept in the material. Similarly, Mtvn09 'I take part in mathematics competitions' tries to understand at what level students are motivated in taking part in the mathematics activities. Additionally, item Mtvn10 'I do mathematics more than two hours a day outside of school' seeks to find out whether students are motivated to learn mathematics at their own time outside of school.

The items Mtvn11 'I have my homework finished in time for mathematics class' and Mtvn12 'I work hard on my mathematics homework' gauge to measure if students are motivated to do their mathematics homework. Item Mtvn13 'I keep my mathematics work well organised' desires to gauge students' motivation level when their math work is organised. Moreover, item Mtvn14 'I talk about mathematics problems with my friends' investigates how students are motivated to share their mathematics work with student mates. Items Mtvn15 'I listen and pay attention in mathematics class' and Mtvn16 'I avoid distractions when I am studying mathematics' seeks to examine how students are still motivated and engaged in mathematics despite distractions from peers. Item Mtvn17 'Mathematics is one of my favorite subjects' aims to discover the motivation level when mathematics becomes one of their favorite subjects. Finally, Item Mtvn18 'I am interested in the things I learn in mathematics', item Mvtn19 'The teacher did not get students interested in the material' and item Mtvn20 'It is interesting to learn mathematics theory' is about students to find out the kind of motivation that increases interest to be engaged in mathematics. These items descriptions measure the single motivation scale in this study.

Data analysis criteria

The Partial Credit model is used to analyse 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 consists 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 & Fox, 2016).

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 standardised mean square (ZEMP) of fit statistics, the mean square value is transformed, with sample size to produce a distribution such a 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 et al., 2011; Bond & Fox, 2016). There are no hard rules on cut-off scores; 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 specifies acceptable fit (Tejada et al., 2011; Bond & Fox, 2016).

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 & 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 & Stone, 1999; Bond & Fox, 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, 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 motivation scale in this study, 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 & Bögeholz, 2010). Hence, in this study, PCM is employed to analyse the items for the motivation scale response categories because it is a parsimonious model and minimises the mean square error. This procedure is useful for surveys such as the motivation scale items, where they are not marked for correct or incorrect answers (Penfield et al., 2008). Survey results from the analysis, appearing in Table 1, demonstrate that data fits the model well which indicates that PCM is a more parsimonious model (Wang & Wu, 2011). The 20 items in the motivation scale are subject to item analysis using the PCM. This is carried out to test the unidimensionality of the 20 items measuring the construct (motivation). This involves examining each item's fit statistics using statistical criteria and procedures.

Table 1 shows that the basic data relating to the responses of the different categories on each item. The proportion of respondents who rated each category varied substantially across items. The proportion varied from 6.1% for strongly disagree for Mtvn01 and Mtvn15, respectively ('I am prepared for my mathematics examinations' and 'I listen and pay attention in mathematics classes') to 52.3% for Mtvn13 ('I keep my mathematics work well organised'). The pattern of agreement across categories for Mtvn14 and Mtvn13 varied, with 31.2% strongly disagreeing or disagreeing with Mtvn13 ('I keep my mathematics work well organised') and 41.6% strongly disagreeing or disagreeing with Mtvn15 ('I listen and pay attention in mathematics class'). These patterns of response affected the mean estimate values of the items. 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 shows that all items fit the model with the INFIT MNSQ criteria of 0.6 to 1.40 (Bond & Fox, 2007, 2016). However, the t- values of Mtvn25 ('The teacher did not get students interested in the material') is 6.8, which is not within the acceptable fit criteria of -2 to 2, and as such was non-significant for the model. Further, the item thresholds are disordered and had a low discrimination index of 0.21. The researcher decided to delete the item due to violation of the Rasch model requirements (Wu & Adams, 2007; Wu et al., 2016). The results of the final run of analysis shown in Table 1 indicates significant improvement on the statistical fits of the items. However, Mtvn06, Mtvn12, Mtvn17 and Mtvn18 t-values are still above the criteria discussed before despite significant changes in their values. Since this is not a "high-stakes" test, though a more lenient approach was taken especially with the t-values of those four items.

Moreover, Table 1 demonstrates the different range of item endorsement of the 20 calibrated survey items from -1.47 to 1.74 logits and is connected to a standard error of -0.03 to 0.18 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 (rpb) of the items in Table 1 ranges from 0.21 to 0.66. 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 & Adams, 2007; Wu et al., 2016; Quaigrain & Arhin, 2017). It is also evident that examinees endorsed the items with higher options more frequently than lower options (Wu & Adams, 2007; Adedoyin & Mokobi, 2013).

Table 1. Analysis outcome of the Rasch measurement model (n=729).

	Proportion responding in each answer category				Estimate values (logits) for items and infit (MNSQ)				Item threshold		
Item code	1	2	3	4	Estimate/(SE)	Infit MNSQ	ZSTD (t)	Pt Bis	1	2	3
Mtvn01	6.1	21.1	45.3	26.9	0.23 (0.04)	1.02	0.4	0.46	-1.09	0.16	2.8
Mtvn02	2.1	11.2	50.4	36.3	0.21 (0.04)	0.98	-0.4	0.55	-2.12	-1.27	1.47
Mtvn03	1.1	6.1	49.6	43.2	-0.69 (0.04)	1.06	1.0	0.39	-1.81	-0.21	1.12
Mtvn04	6.4	28.3	42.2	22.5	-1.47 (0.05)	1.01	0.2	0.36	-1.43	-1.32	0.89
Mtvn05	2.7	20.5	45.6	23.1	-0.99 (0.04)	1.14	1.9	0.29	0.49	1.63	2.23
Mtvn06	4.3	19.2	40.5	35.3	0.14 (0.04)	1.15	2.3	0.38	0.47	1.7	2.37
Mtvn07	1.1	5.1	38.9	54.7	-0.14 (0.04)	1.10	1.8	0.39	-1.17	-1.29	0.88
Mtvn08	3.5	7.7	54.4	33.9	-0.58 (0.04)	1.00	-0.0	0.46	-0.75	0.39	2.17
Mtvn09	1.6	17.3	48	32.5	1.74 (0.03)	1.08	1.6	0.52	-1.7	-0.45	1.33
Mtvn10	2.1	7.5	42.1	48.0	1.34 (0.03)	0.99	-0.3	0.56	-2.17	-0.95	0.19
Mtvn11	1.6	5.1	20.8	72.5	0.92 (0.04)	0.97	-0.6	0.56	-0.46	1.78	2.76
Mtvn12	2.1	7.5	43.5	46.9	-0.01 (0.04)	0.86	-2.4	0.63	-1.1	-1.05	0.62
Mtvn13	52.3	36.8	7.2	3.2	0.34 (0.04)	0.97	-0.7	0.57	-1.03	0.26	2.37
Mtvn14	4.5	26.7	44.3	24.5	0.13 (0.04)	1.08	1.5	0.48	-0.84	1.36	2.28
Mtvn15	6.1	35.5	41.9	16.5	-0.67 (0.04)	0.89	-2.0	0.55	-1.49	0.5	2.45
Mtvn16	1.1	4.5	36.5	57.1	-0.07 (0.04)	1.10	1.9	0.44	-2.15	-0.5	1,26
Mtvn17	0.3	1.3	9.1	89.1	0.33 (0.03)	0.90	-2.1	0.66	-2.57	0.31	1.91
Mtvn18	0.3	1.1	15.2	83.2	-0.44 (0.04)	0.83	-2.2	0.64	-1.29	-0.91	1.16
Mtvn19	43.7	23.2	20.0	13.1	0.49 (0.03)	1.37	6.8	0.21	-0.29	-1.29	1.16
Mtvn20	12.3	39.2	38.1	10.1	-0.35 (0.18)	0.98	-0.3	0.48	-2.76	-1.62	0.72

Note: Separation Reliability = 0.997 ,Chi-square test of parameter equality = 5809.80, df = 19, Sig Level = 0.000

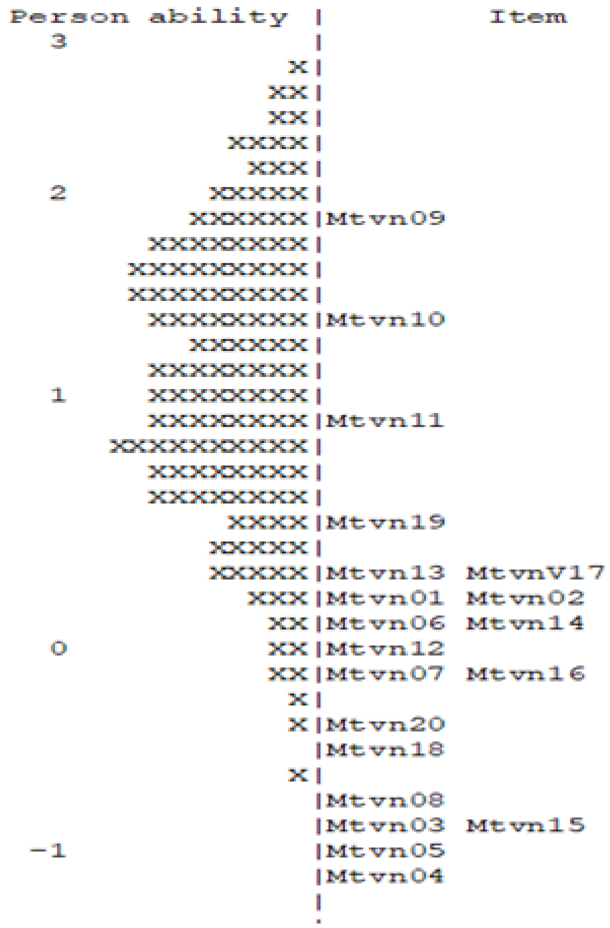

Figure 1. Wright-map of the 20 items of motivation scale as a single level factor.

Figure 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 higher motivation and the items are easy for them to respond. These items are easy because they are located below logit -1 and respondents with both low and high ability level answered the items correctly. The 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 motivation scale questionnaire

The main purpose of this study is to provide more information about improving the questionnaires of the motivation scale. This is because high motivation leads to greater aspiration in mathematics= and science-related fields. As such, as shown in Table 1, item Mtvn19 does not satisfy the Rasch model's statistical criteria and threatens the validity of the motivation scale and is not supporting the unidimensionality structure. This means the item violates the Rasch model's criterion and there is lack of consistency in interpreting the underlying measure. The item is not measuring the same latent construct as the rest of the items in the survey. Infit of 1.37 of Q19 ("The teacher did not get students interested in the material") represents an uncertainty in the data. This item does not conform to the Rasch model's criteria and is deleted. Apart from this item, the model fits the data well.

The person-map in Figure 1 (from left to right) is employed to assess the motivation scale on which both item and the respondents are calibrated on a logit scale. In Figure 1, the numbers on the far left are from -1 (low motivation) to around +3 (very high motivation). The relative item difficulty is plotted on the right side of the scale and personal motivation estimates on the left side of the same scale on the person-map. The respondents at the top of the map represent higher motivation to endorse the questions while the person at the bottom demonstrates low motivation 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, 2007, 2016). The logit zero on the person-map is set at the average item difficulty and overall, the mean motivation of students is higher than the average difficulty. The positive logits values represent the items that demand highest level of motivation. Students' motivation and current item difficulties are less widely spread, but there are major gaps at the top of the maps where students' motivation does not match the high response level items and at the bottom where more items matched low motivation. The results indicated that easy items are required to meet the need of low motivation participants. In addition, five items in the person-map do not correspond to the respondents' endorsement motivation and are very easy (Mtvn03, Mtvn04, Mtvn05, Mtvn08 and Mtvn15). Consequently, respondents have more than a 50 percent probability of endorsing the items accordingly (Boone et al., 2011), while the Rasch analysis shows that motivation parameters are higher and most of the items had slightly inappropriate coverage. The results of the Rasch model thus demonstrate room for improvement of the motivation scale questionnaires.

The study contributes to the methodological significance through reliability and validity of a mathematics motivation scale using two psychometric approaches (unidirectionality and separation-reliability index) as a way of comparison. This research study involves questionnaires that examine motivation 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 motivation scale has advantages and disadvantages of the psychometric properties.

The use of a motivation scale questionnaire in research and instruction

The researchers, teachers and other educators will be able to readily assess students' motivation to learn mathematics if the motivation scale is further improved as stated above. In terms of research, these motivation scale questionnaires can be used to find the relationship between other educational variables through statistical tests. For instance, the students' motivation to learn mathematics differs from their career goals, parent involvement in 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 motivation in learning mathematics. The questionnaires can be used as an instructional tool to find reasons for the decline in motivation among students that can assist teachers to adjust to different teaching styles to develop a conducive learning environment that motivates students. It also assists teachers to identify unmotivated students and foster a positive teaching relationship with students. Moreover, the principals/head teachers and faculty heads could track low-motivation students 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 student motivation by providing alternative programs for students at risk and by reorganising schools.

The students' scores on the motivation scale produce 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 motivation scale's total score. In addition, the items of the motivation scale instrument are Likert-type scales, which could be regarded as an ordinal scale. The ordinal scale does not have the same distance between a score of 1 (Strongly disagree) and 2 (Disagree), and a score of 3 (Agree) and 4 (Strongly agree); it is thus not permissible to add the scores of all item responses. The logit scores are generated through consideration of each item difficulty and the transformation of ordinal scales to interval scales.

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

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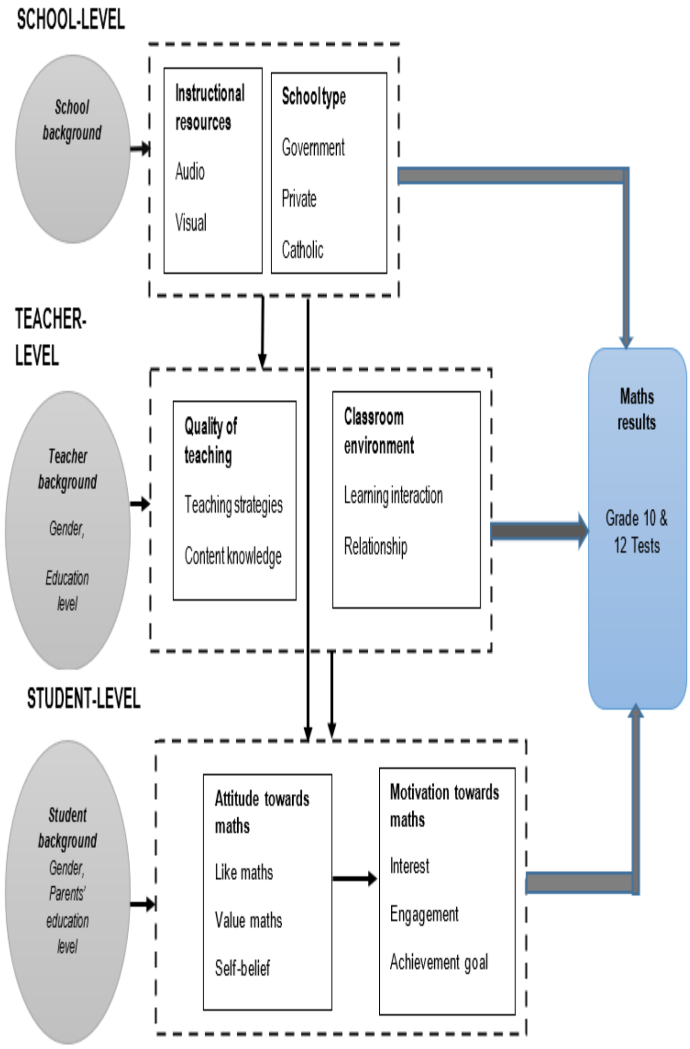
Appendix

Appendix A: Summary of items in the motivation scale used in the study.

Item code	Item Text	Item originated from/Item No
Mtvn01	I am prepared for my mathematics examinations	PISA (36c)
Mtvn02	Jobs that require mathematics skills seems interesting to me.	TIMSS (20j)
Mtvn03	Learning mathematics will help me get ahead in the world	TIMSS (21a)
Mtvn04	It is important to do well in my mathematics class	TIMSS (21b)
Mtvn05	Doing well in mathematics will help me get into university/colleges.	TIMSS (21e)
Mtvn06	Learning mathematics will give me better jobs in the future	TIMSS (21i)
Mtvn07	Learning mathematics is worthwhile for me because it will improve my career prospects	TIMSS (21f)
Mtvn08	I keep studying until I understand mathematics material	PISA (36e)
Mtvn09	I take part in mathematics competitions	PISA (38d)
Mtvn10	I do mathematics more than 2 hours a day outside of school	PISA (38e)
Mtvn11	I have my homework finished in time for mathematics class	PISA (36a)
Mtvn12	I work hard on my mathematics homework	PISA (36b)
Mtvn13	I keep my mathematics work well organized	PISA (36i)
Mtvn14	I talk about mathematics problems with my friends	PISA (38a)
Mtvn15	I listen and pay attention in mathematics class.	PISA (36f)
Mtvn16	I avoid distractions when I am studying mathematics	PISA (22h)
Mtvn17	Mathematics is one of my favorite subjects	TIMSS (20i)
Mtvn18	I am interested in the things I learn in mathematics	PISA (31f)
Mtvn19	The teacher did not get students interested in the material	PISA (35e)
Mtvn20	It is interesting to learn mathematics theory	TIMSS (20e)

Appendix B: Proposed theoretical framework for the study (OECD, 2004 & OECD, 2010).



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