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Validity and reliability of the needs analysis instrument for the mathematics problem-solving module

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Abstract

This research's objective is to investigates the reliability and validity of the needs analysis instrument for mathematics problem-solving based on the computational thinking module among primary school mathematics teachers. For the needs analysis phase, the researchers applied a quantitative method involving a questionnaire. The instrument calibration method is test of language validity, content validity, empirical validity and reliability. The instrument's reliability was tested in a pilot study involving 50 primary school mathematics teachers. The pilot study was analyzed using SPSS version 26. The pilot test results show that Cronbach's alpha value for Construct A: computational thinking skills is 0.786, Construct B: problem-solving skills is 0.772, and the need for the problem-solving module is 0.775. Finally, the researcher expects that this instrument will assist other researchers in the needs analysis phase of developing a mathematical module based on computational thinking in problem-solving.

Keywords: Validity, reliability, mathematics, module, computational

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Introduction

Students learn to solve mathematical problems at varying speeds, but it is crucial that students have the grit and creativity to do so, especially when they learn how to deal with failure or settle disagreement. Additionally, problem-solving is one of the most crucial abilities students may learn since it allows them to handle more complicated interpersonal and academic challenges as they become older. Experts agree that having the confidence to tackle problems is a "critical skill for increasing accessibility particularly in mathematics". Mathematical problem-solving skills teach students how to handle more challenging situations as they become older (Valovičová et al., 2020). Students learn to think in terms of manageable stages as they: Identify Problems, Brainstorm Potential Solutions, Test Appropriate Solutions, and Analyze Results by applying problem solving skills in the classroom.

Besides that, problem-solving skills has always been seen as a fundamental component of mathematics, learning mathematics as well as mathematics pedagogy. This was the fundamental reason why problem-solving skills had been stressed in elementary education from the very beginning stage. The National Council of Teachers of Mathematics (NCTM) found in 2000 that problem-solving is not just an objective of mathematical learning but also a strategy and a pattern of thinking(Mundy, 2000). Besides that, students must sharpen their minds and expand their capacity to emphasize their problem-solving ability. Thus, students' mathematical performance is not just impacted by individuals; teachers also have an essential part in students' achievement (Maamin et al., 2021) . Teachers have to do their professions in addition to improving their teaching methods. Teachers must update and stay current with the many social media platforms that students use, as well as understand how to utilize them responsibly while instructing students in problem-solving skills.

As previously stated, problem-solving is a fundamental skill, but it may be challenging to teach. Many teaching and learning techniques may be used to assist students in understanding this critical information such as following the problem-solving process step by step, ask open-ended questions, promote the drilling method, cooperative learning and pair learning. However, sophisticated nations like the USA, Australia, England, and even Finland highly implement computational thinking in solving problems as a talent in their primary and secondary schools.

Computational thinking in mathematics is a basic skill that needs to be developed early (Wing, 2008). She stated in her foundational work on computational thinking that it "represents a generally applicable attitude and skill set that everyone, not just computer scientists, would be eager to acquire and apply." (Wing, 2006). It is an important tool that can be used in many areas of life, from studying to solving problems. Computational thinking has the ability to contribute to mathematical problem solving and mathematical thinking because of its heavy emphasis on problem solving.

As a result, Computational thinking might be usefully addressed in mathematical education (Borkulo et al., 2020). So, teachers should be highly trained regarding Computational thinking in math education. Although teachers have been exposed to many introductory courses at the school and district level, teachers still lack expertise training and readily accessible problem-solving skills (Marsilah Anum et al., 2021)

Teaching problem-solving is essential in any classroom but finding engaging and effective resources can be challenging. Note that our computational thinking approach to teaching method is perfect for implementation at the classroom level (Hsu, 2019). However, Reichert et al., (2020) claims that students' knowledge of computational thinking is quite inadequate, making it difficult for them to be effectively incorporated into instructional procedures, particularly in basic school. Therefore, the researcher is developing instruments to determine if there is a need for a computational thinking problem-solving module for career Year 4 mathematics teachers on problem-solving skills.

Instrumentation is one of the critical aspects of research. Without the right tools, conducting the research with high quality is impossible. An instrument is a tool for collecting data. It is a machine that helps to understand and make sense of the world around people. Apart from that, instruments allow us to quantify and measure things, which is how we learn and grow as scientists (Heale & Twycross, 2015).

An instrument must be validated and researched before it can be used to collect data. The reliability score should be within the limit to ensure the accuracy of the data collected. Hence, the relationship between content validity and instrument reliability is crucial to instrument development. It is crucial to confirm that the measurement is reliable and that the instrument is measuring what it is meant to be measuring (Jackson, 2006).

There are three types of validity that are given more importance in educational research: face validity, construct validity, and criterion-related validation (Oluwatayo, 2012). When developing a study, it is vital to possess a clear understanding validation mentioned. When selecting an instrument to measure a construct, it is important to first determine the validity of the instrument. An instrument's ability to measure the research construct's properties is a need for validity. Validity is not an instrument's quality but rather the quality of the results obtained by an instrument when it is utilized to assess a certain group of respondents. Thus, it is essential to obtain valid evidence for any study that uses an instrument to gather data.

Data collection is an important part of any research project. The appropriate data must be gathered for the study to reach the right conclusion. In addition, the quality of the instrument used determines the accuracy and reliability of the research. Thus, instruments must be tested and calibrated accurately to obtain valid data. There are many tests that can be done to determine the quality of an instrument, but the most common ones include validity and reliability tests.

Therefore, this article elaborates on the validating process with respect to the needs analysis instrument for the mathematics problem-solving module among primary school teachers. The instrument is compiled and validated in the form of a questionnaire. Note that the instruments in this study were used to measure the need for a mathematics problem-solving module to improve teachers' problem-solving teaching in the topic of Measurement. The question that will be answered in this paper is how is the reliability as well as the validity of the developed needs analysis instruments?

The purpose of this study is to evaluate the reliability and validity of the needs analysis instrument used in the mathematics problem-solving module. Hence, proper instruments need to be used for data collection to achieve the purpose of this study. This instrument can be adapted or developed according to the need of the research. The instruments should be tested for validity and reliability before data collection (bin Darusalam & Hussin, 2016). Questionnaires have always been a preferable choice of instrument for social science studies.

Methodology

2.1 Participants

To develop and evaluate reliability, a sample of 50 primary school teachers from four Malaysian states—Perlis, Kedah, Pulau Pinang, and Perak—who have mathematics as their main subject were selected. An instrument must first be validated by experts before it can be used. Here, identifying the subject matter experts is also important. According to Berliner (2004), it takes teachers about 5 to 7 years to acquire high skill levels to consider an expert. As a result, experts were chosen for this study based on their expertise and experience in their field over a period of 10 to 16 years. Based on that context, four experts were chosen to validate the instrument's language, and four further experts for content validation.

2.2 Malay language experts

Therefore, each instrument will be validated by seven experts with over seven years of working experience before using it in the actual data collection. The selection of the number of experts is based on the recommendation of (Lynn, 1986), Polit & Beck (2006) as well as Polit et al. (2007), where a minimum of four experts is needed to evaluate the instruments' content validity. The researcher employed experts for language validation, including a government Teachers Training Institute professional with 16 years of classroom teaching. Another expert comes from Malaysia's Institute of Language and Literature or DBP. The third expert is a primary school teacher with 15 years of teaching experience. Table 1: Profile of experts involved in the language validation process. Correspondingly, the researcher proceeds with making the necessary correction after language validation.

Table 1: Language validation experts

Expert	Profile	Department	Years of experience in teaching
1	Malay department Lecturer	Teachers Training Institute Malaysia	16 years
2	Malay language Officer	Institute of Language and Literature DBP	19 years
3	Malay Language Teacher	Primary school in Malaysia	15 years
4	Malay Language Teacher	Primary school in Malaysia	16 years

2.2 Content experts

Content Validity Index (CVI) is particularly beneficial in gathering additional data to evaluate an instrument's content validity. Therefore, the CVI value will be more appropriate to utilize in this study to measure an item's potential to maintain the quality of the instrument when applying it. To determine the CVI, the researcher seeks the help of experts.

There are four in the field of Mathematics Education were identified and included in the validation process. Four experts were chosen by the researcher to review the context of the mathematics and problem-solving concepts used in the instrument for content validation. The experts come from various fields; they include two district education officers, a Malaysian Teachers Training Institute lecturer, and a primary school teacher. They all have a minimum of 10 to 16 years' worth of experience. Table 2 below shows the list of experts involved in content validation.

Table 2: Content validation experts

Expert	Profile	Department	Years of experience in mathematics
1	School Improvement Specialist Coach (SISC+) of Mathematics	District Education Office	16 years
2	School Improvement Specialist Coach (SISC+) of Mathematics	District Education Office	10 years
3	Mathematics Lecturer	Teachers Training Institute Malaysia	10 years
4	Master Teacher of Mathematics	Primary school in Malaysia	10 years

The CVI calculation was carried out based on Lynn (1986). Note that CVI comes in two different forms. The two are CVI for scale (S-CVI) and I-CVI for items (I-CVI). The CVI of an item is determined by dividing the total number of experts by the number of experts who gave the item a three or four. If there are five or fewer experts, they should all concur on the content validity. Therefore, the accepted CVI value should be 1 for three experts (Polit & Beck, 2006);(Lynn, 1986), while 0.80 to 1.00 is also an accepted range (Rubio et al., 2003). This calculation is crucial to determine the content relevance with respect to the items on an instrument. The items with a CVI value less than 1 will either be removed or modified to revalidate. The validation form and calculation table for I-CVI and S-CVI were based on the recommendation of Yusoff (2019).

2.2 Reliability test

The degree to which an instrument regularly measures what it is meant to be is known as its dependability. By evaluating the inclusion as well as exclusion criteria of the participants and testing the instruments used for measurements in the study, a pilot study is conducted to determine the viability of the investigation. In this research, a pilot study with 50 teachers was conducted to assess the instruments' reliability. The sample selection was based on the recommendation of Creswell (2014) that a minimum sample of 30 is required to carry out a pilot study. The instrument's reliability was expressed by employing Cronbach's alpha coefficient. According to Chua (2020b), Cronbach's alpha values of 0.65 to 0.95 are satisfactory.

A lower coefficient value of less than 0.65 shows the ability of the instrument to measure the variable is low. In contrast, a coefficient above 0.95 means that there are overlapping or similar items on the questionnaire. On the other hand, Fraenkel et al. (2012) stated that reliability should be at least 0.70 and preferably higher.

Results

3.1 Validation

The questionnaire contains three parts: awareness of computational thinking in solving problems, the problem faced by maths teachers while teaching problem-solving questions and the last part about the need for a mathematics problem-solving module.

3.1.1 Language Validity

This instrument was evaluated by four language experts from various disciplines. This phase's main objective was to improve the language-related standards of the instruments that were developed. Data was gathered using modified indicators created in response to Yohana et al., (2019)'s study. The following table shows how the indicator was evaluated by language experts:

Table 3: Summary of experts' validation

No	Indicators	Average Score	Criteria
1.	The given instructions in the instrument are clear and precise.	100 %	Very good
2.	The given instructions in the instrument are short and clear.	75 %	Good
3.	The language used in the instrument is easy to understand.	100 %	Very good
4.	The mathematic terms are clearly used in the instrument.	100 %	Very good
5.	Proper grammar and spelling are used in the instrument.	100 %	Very good
6.	The words used in the instrument are relevant and familiar to the respondent.	100 %	Very good

The expert's response scored a total average percentage of 100% with the criterion of "Very Good" for the language portion of the instrument. This demonstrates the high level of quality and usability of the instrument's language. Consequently, the researcher proceeded with content validation since the instrument met all the language validation criteria.

3.1.2 Content Validity

Each element in the indicator was carefully examined by experts for the content validity. The items' quality was also examined. The important aim of this validity is to ensure that those items are really relevant and important in order to accomplish the research's goal. Therefore, the Content Validity Index (CVI) was produced using all experts.

The obtained I-CVI, S-CVI/Ave as well as S-CVI/UA satisfy satisfactory levels based on experts' judgments of item relevance. As a result, every expert assigned a score of 1.00 for each and every item in the instrument. Experts in Agreement is 4 for all the item, I-CVI is 1.00, UA is 1, S-CVI/Ave is 1.00.

The table 4 shows The Content validity index (CVI) ratings on the item scale by four experts. As a result, the instrument has attained a satisfactory level of content validity with the score of Here, the experts concur that the instrument is suitable for the intended use.

Table 4: The Content validity index (CVI) ratings on the item scale by four experts

No	Item	I-CVI
	Construct A: Computational thinking awareness	
1.	I am aware that computational skills should be emphasized, much like reading, writing, and counting skills, in order to help every child improve their analytical capabilities.	1.00
2.	I am aware that addressing mathematical issues requires sophisticated computing skills.	1.00
3.	I am aware that the process of abstraction entails disassembling a complex matter or system into smaller parts.	1.00
4.	I am aware that pattern recognition techniques are a process of identifying similarities that exist in several problems or in the same problem.	1.00
5.	I am aware that the decomposition technique is a method for classifying a problem's significant components from its less important points to solve mathematical problems.	1.00
6.	I am aware that algorithms are a collection of rules, or a series of instructions used to solve mathematical problems.	1.00
7.	I am aware of the teacher's responsibility in teaching computationally based mathematics problem solving.	1.00
8.	I solve math issues using computational skills.	1.00
9.	I am aware that computational skills extend the range of mathematical problem-solving strategies.	1.00
	Construct B: Problems that teachers experience in teaching problem solving in topic measurement	1.00
10.	When it comes to the measurement topic, I have trouble deciding which mathematical problem-solving strategies to apply.	1.00
11.	I had to teach mathematical problem-solving in the topic of measurements using a general technique.	1.00
12.	When presenting mathematical problem-solving in measurement-related issues, I had to utilize my own techniques.	1.00
13	I don't have a complete guidebook on how to approach mathematical measurement difficulties.	1.00
14.	When I teach mathematical problem-solving in measurement topics, it is difficult for me to change my teaching methods and techniques.	1.00
15.	I occasionally have trouble changing length units (such from m to km) while discussing measurement topic.	1.00

16.	I have trouble getting pupils to understand the concept of unit exchange while discussing measurement.	1.00
17.	When discussing measurement and converting units of measurement (km, m, cm, mm), I had to force my pupils to memorizing formulae.	1.00
18.	I am having trouble ensuring that the student understand the needs of the measurement topic's problem-solving questions.	1.00
19.	I had to teach students how to solve mathematical problems by using simple questions.	1.00
20.	I'm confused of the best teaching strategy to use when introducing problem solving in the topic of measurement	1.00
21.	I am facing problems when translating the information found in the math problem solving questions on the topic of measurement for student understanding.	1.00
22.	I have difficulty in ensuring that my students synthesize information from math problem solving questions in measurement topics.	1.00
23.	I face difficulties in ensuring that my students categorize the important information and the less important information found in the mathematical problem-solving questions in the topic of measurement	1.00
24.	My students are less interested in solving mathematical problems in the topic of measurement.	1.00
25.	My students often have difficulties when answering problem-solving questions in measurement topics. .	1.00
	Construct C: The needs for a teaching module on mathematical problem-solving	
26.	I need a suitable teaching module to improve my teaching skills in solving mathematical problems in measurement topics.	1.00
27.	I need an accurate teaching module that can enhance the active learning of my students in solving mathematical problems on the topic of measurement.	1.00
28.	I am interested in teaching mathematical problem solving based on computational skills if there is a complete module.	1.00
29.	I need a complete teaching module (Lesson plan, worksheets, assessments) to conduct a perfect teaching session based on computational thinking skills in solving mathematical problems on measurement topics.	1.00
30.	I think that there is a need to develop a mathematical problem-solving teaching module based on computational skills for mathematics teachers in order to improve the quality of their teaching.	1.00
31.	If there was a mathematical problem solving teaching module based on computational skills for the topic of measurement, I would use it in my classroom.	1.00
32.	I need a teaching module that consists of questions and problem solving methods/strategies based on various solving techniques based on computational thinking skills.	1.00
33.	The teaching module should include an introduction to computational skills in the context of solving mathematical problems.	1.00
34.	The teaching module must be produced in the form of a website (Website).	1.00
35.	Questions - questions solving mathematical measurement problems from textbooks, BPG modules and the internet should also be included in the teaching module.	1.00
36.	Activities in this teaching module need to be student-centered to ensure optimal student involvement.	1.00
37.	Mathematical problem solving questions in the teaching module should be based on problems from the real world context and relevant to the students' level of thinking.	1.00

38.	Activities in this teaching module should contain hands-on mind activities to increase students' confidence and satisfaction.	1.00
39.	Activities in this teaching module must use clear and easy-to-understand language.	1.00
	S-CVI/Ave	1.00
	S-CVI/UA	1.00

3.2 Reliability

To determine the reliability of constructs, the researcher uses SPSS. It is recommended that reliability should be at least 0.60 for an exploratory or pilot investigation (Guedeney & Fermanian, 2001). Nawi et al., (2020) have proposed four reliability cut-off values: high reliability (0.70-0.90), moderate reliability (0.50-0.70), good reliability (0.90 and above), and low reliability (0.50 and below). Despite being important for research, dependability is inadequate without validity. In another sense, a test needs to be accurate in addition to being acceptable (Varni et al., 2010).

According to the SPSS version 26, the value of Cronbach's alpha generated for the construct of Awareness of Computational Thinking in Mathematics problem-solving is 0.786; Problems faced by teachers in teaching problem-solving skills is 0.772 and the Need for a Mathematics problem-solving Module is 0.775. Hence, the instrument should be within a satisfactory level of reliability to ensure that the results obtained are accurate. The value of construct 1: 0.786, construct 2: 0.722 and construct 3: 0.775 is within the acceptable range, meaning that the instrument can measure what it intends to measure. Table 5 displays the reliability test outcomes using Cronbach's alpha for the construct.

When there are several Likert questions in the questionnaire, Cronbach's alpha is the most frequently used analysis to establish reliability (Yahya et al.,2021). The value shows that the instrument is within a satisfactory level of reliability, which is greater than 0.700. Therefore, the instrument should be able to measure what it intends to obtain the objective.

Table 5: Cronbach's alpha

Dimension	Cronbach's alpha	Number of items
Awareness of Computational Thinking in Mathematics problem-solving	0.786	10
Problems faced by teachers in teaching problem-solving skills	0.772	17
Need for a Mathematics problem-solving Module	0.775	15
	Total	39

Discussion

The authors' instrument met the demand for information about the level of computational thinking knowledge among mathematics teachers. Additionally, this instrument may be used to highlight the challenges teachers face when introducing students to problem-solving in the topic of measurement. This work provided an updated measurement instrument that could be used to determine the need to problem-solving module for teachers in teaching measurement for their students.

The results of the analysis showed that the survey form was reliable and solid. The content validity was evaluated by a panel of professional experts, who gave it high marks and levels of agreement for pertinence, relevance, and clarity in the wording of the items. The validity of the items in the instrument contained acceptable CVI values and corrected items based on expert comments. In addition to appropriate values, Cronbach's alpha values of construct A: 0.786, construct B:0.772, and construct C:0.775 were discovered in the reliability test of the instrument.

The systematics steps described resulted in the development of a need analysis instrument with three dimensions (Awareness of Computational Thinking in Mathematics problem-solving, Problems faced by teachers in teaching problem-solving skills, Need for a Mathematics problem-solving Module) and 39 items. These 39 items made it possible to collect data on a variety of topics, including the level of computational thinking among math teachers and the types of difficulties that teachers of problem solving faced. as well as the final 15 items will assist in determining whether a problem-solving module for primary school teachers is necessary.

The final version of the instrument, which was obtained after the development and validation processes, did not contain any items referring to other general teaching techniques in mathematics education, with the exception of the computational thinking. A few items were removed by experts because some items were redundant or reflected the same challenges teachers have when attempting to teach problem-solving in the topic measurement. Experts also made some changes on sentences structure of the items to ensure that the meaning of the item measuring computational thinking is accurately stated.

The development of a computational thinking instrument for problem solving mathematics assessment reference is a direct assessment since teachers instantly demonstrate mastery of skills when the assessment is conducted. Meanwhile, this instrument was specifically developed for primary school mathematics teachers. When we refer to teachers who teach mathematics, we also include teachers who teach mathematics as their major or minor subject. This instrument can also be used by teachers in rural and township primary schools. Furthermore, during the reliability test, the math teachers were requested to include an appropriate comment in their instrument responses. As a result, no difficulties occur, such as a lack of time to finish the instrument.

Conclusion

This article seeks to explain how the needs analysis instrument for the mathematics problem-solving module was created and evaluated for its validity and reliability. To secure an instrument's overall validity, content validity must be ensured; this must be done by taking into account prior best practices and data. The instruments' results for content validity demonstrate that the content validity is good and acceptable. In other terms, the instruments created can measure what they set out to within their limitations. A quality instrument must not only have content validity but also achieve high reliability to consistently deliver the same outcomes. A measurement tool is thus deemed reliable and strong when there is proof of its reliability and validity (Frost et al., 2007). Overall, the needs analysis instruments' reliability and validity are satisfactory and can be employed for the purposes of this study. As a result, this instrument is being developed systematically with a high level of commitment from experts. According to the findings, this instrument is of high quality and should be utilized by primary school teachers to measure their competence of computational thinking in problem solving. Furthermore, as a main objective of the instrument, this instrument is highly recommended to determine whether a module of computational thinking in problem solving is necessary for primary school teachers.

Recommendations

This research provides details on how to validate and determine the reliability of a mathematics problem-solving module's needs analysis instrument in mathematics education. This tool has significant educational implications, particularly for mathematics teachers in primary schools. Future research can potentially make more progress with the help of a larger database such as Scopus, Web of Science, Pebmed and so on. It is anticipated that this study will inspire more investigation on how to enhance problem-solving skills, specifically in Malaysia concerning the mathematics subject.

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