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Development of a Real-time Digital Learning Platform for Diagnosing Degrees of Mathematical Competency

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ABSTRACT

The research aims to develop and verify a real-time digital learning platform for diagnosing the degree of mathematical competency of seventh-grade students. A total of 1,559 students from four regions of Thailand and six experts participated in this research. The researchers employed a design-based approach and the Multidimensional Coefficient Multinomial Logit Model to evaluate the effectiveness of the real-time digital learning platform. The measurement tool consists of two aspects, namely mathematical measures and the construction of knowledge dimensions, with 58 items to simulate students' responses to the three respective content constituents: number and algebra, measurement and geometry, and statistics and probability. The findings showed that the multidimensional model offered a significantly better statistical fit in measurement, geometry, statistics, and probability, while numbers and algebra fit better in the unidimensional model. There were positive, strong, and significant correlations between the dimensions. The findings indicated that all items fit the OUTFIT MNSQ and INFIT MNSQ, which are between 0.75-1.33. The findings revealed that the internal structure when it came to evaluating the degrees of students' mathematical competency using the Wright map and the Multidimensional Test Response Model conformed with the quality of the digital learning platform in terms of its usefulness, accuracy, and feasibility. This real-time digital learning platform for diagnosing the degree of mathematical competency can be accessed from anywhere with an internet connection, making education more accessible to a wider audience, including individuals in remote areas or those with physical disabilities.

Keywords: Content constituent, construction of knowledge, degrees of mathematical competency, mathematical measures, real-time digital learning platform

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INTRODUCTION

The rapid development of technology has indeed prompted the integration of various technological tools into teaching and learning processes. Digital diagnostic tools are crucial in assessing and enhancing the learning experience, particularly in the post COVID-19 pandemic (Buakhamphu, et al., 2024). According to Thisopha et al. (2023), digital diagnostic tools can provide real-time assessments of students' understanding of the material. In the post-COVID world, education should make free and open-source technologies available to teachers and students. Open educational resources and open-access digital tools must be supported. Education cannot thrive with ready-made content built outside the pedagogical space and human relationships between teachers and students (International Commission on the Futures of Education, 2020). The COVID-19 pandemic has transformed the education system and created enormous disruption (Maisa et al., 2021) that needs the development of a real-time digital learning platform to diagnose students' mathematical competency. In addition, Kesorn et al. (2020) emphasized the importance of mathematics in providing practical knowledge and stimulating students' learning. Kantahan et al. (2020) highlighted that an interactive and creative digital learning platform focused on individual needs and competencies is required in this new era. In this study, the theoretical framework applied a holistic approach that combines assessment design, data analysis, feedback mechanisms, and ethical considerations to ensure that the platform serves its educational purpose and provides reliable and valid measurements of student outcomes.

Previously, the mathematics teacher was the primary source of knowledge, and learning was restricted to the classroom. Even though the role of the mathematics teacher remains undiminished in the current educational setting, students now have several resources or a wealth of opportunities literally at their fingertips, allowing them to self-direct and take control of their learning and assessment processes (Harman, 2021). According to Harman, all digital platforms, with their various functions and features, can support any type of learning, namely, in the form of online learning, classroom learning, and blended learning, hence fostering overall academic growth in students. Harman (2021) also explained the advantages of using digital learning platforms: easy access to information, up-to-date content, advanced reporting, multimedia learning, new communication channels, 24-hour access to learning resources, and self-directed study.

Phaniew et al. (2021) defined mathematical competency as a student's ability to engage in exploration, critical thinking, and logical reasoning. Mathematical competency goes beyond rote memorization and emphasizes the importance of understanding and reasoning through mathematical concepts and problems. The essential constituents of mathematical competency are numbers and algebra, measurement and geometry, and statistics and probability. Therefore, the awareness of these content constituents and how they interact make up the basic stages of precision, stages, and problem-solving play a vital role in developing students' mathematical competency (Yulian & Wahyudin, 2018). According to these researchers, the role of the mathematics teacher is to allow students to acquire significant and evocative mathematical concepts and procedures, using interactive mathematics classes that permit every student to engage in stimulating, thought-provoking practices when it comes to learning mathematics. Students need to develop several mathematical competencies to successfully learn mathematics. In addition, Milgram (2007) also viewed mathematical competence as having five dimensions: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. These mathematical competencies should be developed in an integrated and balanced way for students to learn mathematics (Kilpatrick et al., 2001).

The definition of mathematical competence is further supported by Junpeng et al. (2018), who identified mathematical competencies as the procedure of employing mathematical understanding. Junpeng et al. (2018) revealed that numerous attempts to pilot and review students' answers with regard to open-response questions in order to assess their capabilities are important to diagnose their degrees of mathematical competency. Therefore, Junpeng et al. (2018) identified mathematical measures (MME) as one of the mathematical competence dimensions. They state that MME is the ability to execute mathematical practices elastically, precisely, competently, and correctly. On the other hand, Biggs and Collis (1982) defined the construction of knowledge (CKL) as it appears in the SOLO taxonomy, as a mathematical competence dimension that recognizes, illustrates or clarifies the degree of knowledge on the part of the student to establish the degree of student understanding outcomes. In other words, the CKL dimension is characterized as understanding mathematical concepts to solve mathematical problems using the students' capacities for logical thinking and justification (Junpeng et al., 2018).

Kepner and Huinker (2012) revealed that mathematical practices, as expectations of student behaviors, depend on essential methods and skills found in mathematics education and have long-lasting consequences. Therefore, each assessment claim indicates what would be expected of a student with regard to demonstrating competencies across a range of content and practices (Kepner & Huiner, 2012). They further emphasized that the consortia's promise of assessing and reporting on multifaceted student performance entails assessment assignments and items that go beyond select-response items to construct-response items. Furthermore, Adom et al. (2020) stated that there is a constant need to measure the outcomes or the quality of responsiveness of the teaching and learning referred to as assessment in the teaching-learning environment. This essential symbiotic process can occur before, during, and after the teaching process.

In addition, Fowler et al. (2019) suggested that mathematics teachers should structure learning activities in such a way as to not only demonstrate content but involve students in profound acquaintance with mathematical thinking by utilizing an appropriate pedagogy that intertwines the mathematical competencies, leading to the emergence of lifelong users of mathematics. They recommended the use of digital tools to support the presentation of mathematical competencies by delivering active learning, as a result of which students are able to resolve mathematical problems confidently, independently, and collaboratively, thereby developing their understanding of mathematical concepts and being able to explain their reasoning. Digital learning platforms allow students to experience mathematical concepts that are hard to exhibit in actual circumstances. Through research-proven methods and the skillful incorporation of digital sources, mathematics teachers can meaningfully discover students' interpretations of mathematical competencies (Fowler et al., 2019).

The Thailand Mathematics Curriculum is established across the interface of these content constituents and the four competency constituents. As noted above, the content constituents are number and algebra, measurement and geometry, and statistics and probability. In short, the content constituents depict what is to be learned and understood by students (Thailand Ministry of Education, 2008). On the other hand, the competency constituents of mathematics include understanding, fluency, problem-solving, and reasoning. These constituents illustrate by what means content is investigated or established; that is, it relates to the reasoning and performing of mathematics. Therefore, they offer an eloquent foundation for the development of concepts in the learning of mathematics and have been merged into the content descriptions of the three content constituents. Based on this line of reasoning, the Thailand Ministry of Education has adopted this approach to certifying the mathematical competencies that can be developed throughout the curriculum and become progressively advanced over the years of schooling (Manmai et al., 2021).

The above literature review indicates the challenges researchers face when developing and verifying a measurement model and its interpretation process in every way possible. The motivation for developing a real-time digital learning platform for diagnosing degrees of mathematical competency stems from several critical gaps in theoretical understanding and practical applications in the current educational landscape. It is undeniable that the COVID-19 pandemic has given a major boost to online education. It leads to all schools having already adopted, or being in the process of adopting, a digital learning platform to support learning (Harman, 2021). Moreover, the development of a real-time digital learning platform for diagnosing degrees of mathematical competency is motivated by the need to address theoretical gaps related to individualized learning, dynamic assessment, and cognitive load, as well as practical gaps concerning timely intervention, resource accessibility student engagement, and data-driven decision-making in education.

Maoto et al. (2018) emphasized that mathematics teachers are having difficulties assessing the degree of students' mathematical competency. They need information and skills about what needs to be evaluated in terms of students' mathematics competencies and how to perform such evaluations related to the intended goals of the task. As a result, this research would be timely in providing an exploration of real-time mathematical competency to aid mathematics teachers in easily diagnosing their students' mathematical competencies. Following this line of reasoning, the research aimed to develop and verify a real-time digital learning platform for diagnosing the degree of mathematical competency of seventh-grade students. In this paper, the researchers planned to investigate 1,559 seventh-grade students' answers in a predictable digital assessment process to fix the criteria for measuring the degree of mathematical competency in terms of the three content constituents: number and algebra, measurement and geometry, and statistics and probability. It was followed by developing a mathematical competency measurement model using the Rasch model as a Multidimensional Random Coefficient Multinomial Logit Model (MRCMLM) to analyze the situation. Finally, the researchers evaluated the overall quality of the real-time digital learning platform in terms of diagnosing the degree of mathematical competency on the part of seventh-grade students by using a measurement model involving three aspects: usefulness, feasibility, and accuracy, using heuristic evaluation.

MATERIALS AND METHODS

The researchers employed construct modeling to introduce a real-time digital learning platform in which the three mathematics content constituents were designed diagnostic tasks to measure the degree of mathematical competency on the part of seventh-grade students (Wilson, 2005). Moreover, a design-based research method was adopted from Adams (2005), and the MRCMLM (Adams et al., 1997) was applied to verify the quality of the real-time digital learning platform. Item Response Theory (IRT) assesses the relationship between a student's mathematical ability or trait and their responses to a set of items or questions. The primary idea behind IRT is to model the probability of a particular response to an item as a function of the student's latent trait and the item's characteristics (Linacre, 2005).

The key concepts in IRT include item parameters, latent traits, and test information. Each test item has its own set of parameters, such as difficulty and discrimination. Difficulty indicates how hard the item is, while discrimination measures the item's ability to differentiate. The unobservable trait in this study is the mathematical competency that the test aims to measure. IRT models estimate a student's position on this latent trait. The amount of information a test provides about a student's ability level. IRT helps design tests that maximize information across a range of ability levels (Linacre, 2005).

Population and Sample

The research population consisted of all the seventh-grade secondary school students from the four regions of Thailand: northeast, central, north, and south. A total of 1,559 students were chosen as test-takers using stratified random sampling. It allowed the researchers to obtain a sample population including smart, moderate, and weak students in such a way as to best represent the entire population being studied (Hayes, 2024). According to Wright and Stone (1979), a minimum sample size of not less than 500 individuals is needed to obtain sufficient quality data for analysis when using the multidimensional test response theory. Table 1 demonstrates the distribution of the test-takers who participated in the three assessment tools in terms of the three content constituents.

Table 1
Distribution of the test-takers in the three content constituents

Region	School	Number of test-takers		
		Number and Algebra	Measurement and Geometry	Statistics and probability
Northeast	1	55	49	47
	2	72	71	72
	3	62	63	58
	4	2	3	3
	5	7	6	6
	6	64	66	65
	7	9	7	7
	8	-	2	2
Central	9	52	54	48
	10	51	46	50
North	11	4	2	2
	12	12	11	8
	13	3	3	4
	14	11	12	9
	15	1	1	2
	16	5	5	5
	17	5	5	5
	18	2	3	2
	19	7	5	4
	20	4	4	4
South	21	42	40	38
	22	12	14	13
	23	-	56	53
Total		524	528	507

Source: Authors' work

Research Procedure

Researchers utilized the construct modeling approach Wilson (2005) proposed to design the mathematical competency measurement model. In addition, design-based research was employed as the research design (Vongvanich, 2020) by adapting four building blocks as the sections of the measurement scheme (Wilson & Sloane, 2000). The four building blocks were (1) a progressive standpoint of students' understanding, (2) the association between teaching and measurement, (3) the teacher administering classroom teaching and measurement, and (4) the creation of high-quality evidence. On top of that, the researchers used software and analysis methods, including machine learning algorithms like regression, classification, clustering, and natural mathematical language processing techniques.

In the first phase, the researchers conducted numerous inclusive meetings with mathematics teachers and experts by referring to the basic education core curriculum 2008 (Ministry of Education, 2017) to create three assessment tools. These diagnostic tools were a multiple-choice test with four options in an online testing system entitled "e-MAT-Testing." The e-MAT-Testing approach assessed three main content constituents: (1) number and algebra (21 items), (2) measurement and geometry (20 items), and (3) statistics and probability (17 items). The internal structure of the e-MAT-Testing approach was then formed and evaluated using model fit and interdimensional correlation analysis.

The test results from the first phase were used in the second phase to create an innovative prototype, a real-time digital learning platform for diagnosing seventh-grade students' mathematical competency levels. In the third phase, the researchers utilized MRCMLM (Adams et al., 1997), which is a type of Rasch Model (Rasch, 1960), to generate quality evidence of the value of the real-time digital learning platform for diagnosing degrees of mathematical competency on the part of seventh-grade students.

The researchers analyzed the item fit of the mathematical competency measurement model. Then, they evaluated the degree of student mathematical competency using the Wright map and the Multidimensional Test Response Model. The Wright map was used to validate evidence of the quality of the progress map in each dimension with regard to each content constituent. As a result, the MRCMLM was used to correlate the modeling of items in multidimensional competencies, assess the student's competency parameters, and place the transition points for diagnosing the degree of the student's mathematical competency in each dimension. The ACER ConQuest Version 2.0 program (Wu et al., 2007) was applied to estimate the mathematical competency measurement model parameters.

In the final phase, the researchers revised the heuristic evaluation ideas of Stufflebeam (Kanjanawasi, 2011) to appraise the overall quality of the real-time digital learning platform for diagnosing the degree of mathematical competency of the seventh-grade students in three aspects, namely usefulness, feasibility, and accuracy. Six experts carried out this process. A five-point Likert scale assessment document was employed to measure the experts' interpretation of the real-time digital learning platform, ranging from minimal to most applicable. Table 2 shows the five degrees of applicability, which were determined in accordance with the mean score range.

Table 2
Clarification of applicable degree according to the mean score range

Mean Score Range	Interpretation
1.00–1.49	Minimal applicable
1.50–2.49	Less applicable
2.50–3.49	Medium applicable
3.50–4.49	Very applicable
4.50–5.00	Most applicable

Source: Authors' work

FINDINGS AND DISCUSSION

The researchers adapted the mathematical competency measurement model in relation to the proposals recommended by past researchers that involve the MME dimension (Junpeng et al., 2018) and the CKL dimension (Biggs & Collis, 1982). For each degree of learning competency, an assessment process must be conducted correctly utilizing the most appropriate assessment tool for the three content constituents: number and algebra, measurement and geometry, and statistics and probability.

Creation of a Multidimensional Mathematical Competency Measurement Model

Researchers need to develop assessment tools to provide an overview that truly describes the degree of students' mathematical competency in terms of their abilities.

Internal Structure of the Assessment Tools

The researchers developed three assessment tools consisting of 21 items for the number and algebra content constituent, 20 items for the measurement and geometry content constituent, and 17 items for the statistics and probability constituent. The number and algebra assessment tool consisted of 11 items in the MME dimension and 10 in the CKL dimension. The measurement and geometry assessment tool comprises ten items in each MME and CKL dimension. The statistics and probability assessment tool included eight items in the MME dimension and nine in the CKL dimension. Table 3 shows the internal structure of the three assessment tools with regard to the digital learning platforms.

Comparing the Model Fit

The internal structure of the mathematical competency measurement model in terms of its accuracy with regard to the mathematical competency constructs was performed by comparing the model fit for unidimensional and multidimensional models. The unidimensional model refers to clustering all the items into one dimension. In contrast, the multidimensional model separates items into the MME and CKL dimensions. The findings indicated that the unidimensional model was found to fit significantly better statistically than the multidimensional model with regard to the

Table 3
Assessment tools of the three content constituents

Content constituent	MME (Item)	Total of MME	CKL (Item)	Total of CKL	Total item
Number and algebra	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	11	12, 13, 14, 15, 16, 17, 18, 19, 20, 21	10	21
Measurement and geometry	1, 2, 3, 6, 15, 16, 17, 18, 19, 20	10	4, 5, 7, 8, 9, 10, 11, 12, 13, 14	10	20
Statistics and probability	3, 7, 8, 9, 10, 11, 12, 13	8	1, 2, 4, 5, 6, 14, 15, 16, 17	9	17

Source: Authors' work

number and algebra content constituent. The findings were shown in terms of the Likelihood Ratio Chi-Square G^2 ($\chi^2 = 3.83$, $df = 2$, $p = 0.01$) (Wilson & De Boeck, 2004) as well as the Akaike Information Criterion (AIC) (Yao & Schwarz, 2006) and the Bayesian Information Criterion (BIC) (Schwarz, 1978) which had a higher value in multidimensional concepts for measuring mathematical competencies in terms of the number and algebra content constituent.

However, the findings showed that the multidimensional model was a statistically better fit than the unidimensional model in terms of the measurement and geometry content constituent and the statistics and probability content constituent. It is reflected in the results with regard to the Likelihood Ratio Chi-Square G^2 ($\chi^2 = 10.72$, $df = 2$, $p = 0.01$) for the measurement and geometry content constituent, and the Likelihood Ratio Chi-Square G^2 ($\chi^2 = 7.32$, $df = 2$, $p = 0.01$) (Wilson & De Boeck, 2004). In addition, the AIC (Yao & Schwarz, 2006) and the BIC (Schwarz, 1978) had smaller values in terms of the multidimensional concepts for measuring mathematical competencies for both the measurement and geometry content constituent as well as the statistics and probability content constituent. Table 4 demonstrates the comparative findings of the model fit for the three content constituents.

Interdimensional Correlation Analysis

The researchers continued by examining the correlation between the dimensions of the multidimensional mathematical competency measurement model. The findings indicated that there were positive, strong, and significant correlations between the MME and CKL dimensions, [$r(524) = .78$] for number and algebra content constituent, [$r(528) = .89$], the measurement and geometry content constituent, and the statistics and probability content constituent [$r = (507) = .89$] at a significant level of 0.05. Table 5 elucidates the findings of the interdimensional correlation analysis.

Item Fit Analysis of the Mathematical Competency Measurement Model

All the 58 items' difficulties in the mathematical competency measurement model were examined as presented in Tables 6, 7, and 8. The researchers referred to the criteria proposed by Adams and Khoo

Table 4
The comparison of model fit

Content constituent/ Model	Deviance	N of parameter	AIC	BIC
Number and algebra				
Unidimensional	13123.33	22	13167.33	13183.16
Multidimensional	13127.16	24	13175.16	13192.42
Likelihood Ratio Chi-Square G^2 (χ^2 = 3.83, *df* = 2, *p* = 0.01)				
Measurement and geometry				
Unidimensional	12337.86	21	12379.86	12395.04
Multidimensional	12327.14	23	12373.14	12389.76
Likelihood Ratio Chi-Square G^2 (χ^2 = 10.72, *df* = 2, *p* = 0.01)				
Statistics and probability				
Unidimensional	9560.79	18	9596.79	9609.48
Multidimensional	9553.44	20	9593.44	9607.54
Likelihood Ratio Chi-Square G^2 (χ^2 = 7.32, *df* = 2, *p* = 0.01				

Source: Authors' work

Table 5
Interdimensional correlation analysis

Content constituent	Dimension	MME dimension	CKL dimension
Number and algebra	MME		0.50**
	CKL	0.78*	
	Variance	0.56	0.72
Measurement and geometry	MME		1.38**
	CKL	0.89*	
	Variance	1.37	1.76
Statistics and probability	MME		1.50**
	CKL	0.89*	
	Variance	1.97	1.50

Note. *Represents the correlation value **Represents the co-variances
Source: Authors' work

(1996) and Wilson et al. (2006) to verify the appropriateness of OUTFIT MNSQ and INFIT MNSQ values that have to be between 0.75–1.33. For the number and algebra content constituent, the findings showed that the item difficulties ranged from -0.674 logits (*SE* = 0.096) to +1.227 logits (*SE* = 0.106) and -0.187 logits (*SE* = 0.094) to 2.279 logits (*SE* = 0.142) in the MME dimension and the CKL dimension correspondingly. Moreover, the findings in terms of both OUTFIT MNSQ and the INFIT MNSQ values were between 0.88–1.96 and 0.89–1.22, fulfilling the criteria in terms of the suitability of the digital learning platform with regard to the number and algebra content constituent (Adam & Khoo, 1996; Wilson et al., 2006) as illustrated in

Table 6
Findings of item fit analysis for number and algebra constituent

Item	Difficulty	*SE*	OUTFIT		INFIT		Item score threshold			
			MNSQ	CI	MNSQ	CI	1	2	3	4
MME1	0.878	0.100	1.13	(0.88, 1.12)	1.09	(0.92, 1.08)			0.88	
MME2	0.536	0.095	1.07	(0.88, 1.12)	1.07	(0.93, 1.07)			0.54	
MME3	0.131	0.093	0.99	(0.88, 1.12)	0.99	(0.94, 1.06)		0.13		
MME4	0.760	0.098	1.00	(0.88, 1.12)	0.99	(0.92, 1.08)			0.76	
MME5	-0.664	0.096	0.95	(0.88, 1.12)	0.98	(0.93, 1.07)	-0.66			
MME6	1.227	0.106	1.08	(0.88, 1.12)	1.03	(0.90, 1.10)				1.23
MME7	1.216	0.106	1.04	(0.88, 1.12)	0.99	(0.90, 1.10)				1.22
MME8	1.031	0.102	0.96	(0.88, 1.12)	0.94	(0.91, 1.09				1.03
MME9	0.666	0.097	0.95	(0.88, 1.12)	0.95	(0.93, 1.07)			0.66	
MME10	-0.282	0.093	0.97	(0.88, 1.12)	0.98	(0.94, 1.06)	-0.28			
MME11	-0.674	0.096	1.00	(0.88, 1.12)	1.01	(0.93, 1.07)	-0.67			
			Transition Point				-0.54	0.13	0.71	1.16
CKL12	-0.187	0.094	0.96	(0.88, 1.12)	0.98	(0.94, 1.06)	-0.19			
CKL13	0.960	0.102	0.88	(0.88, 1.12)	0.90	(0.91, 1.09)			0.96	
CKL14	0.729	0.099	0.89	(0.88, 1.12)	0.90	(0.92, 1.08)			0.73	
CKL15	1.013	0.103	0.89	(0.88, 1.12)	0.89	(0.91, 1.09)			1.02	
CKL16	0.193	0.094	0.96	(0.88, 1.12)	0.97	(0.94, 1.06)		0.20		
CKL17	2.279	0.142	1.69	(0.88, 1.12)	1.22	(0.81, 1.19)				2.28
CKL18	1.066	0.104	1.28	(0.88, 1.12)	1.17	(0.90, 1.10)			1.06	
CKL19	1.327	0.109	1.30	(0.88, 1.12)	1.19	(0.89, 1.11)			1.33	
CKL20	0.220	0.094	0.88	(0.88, 1.12)	0.90	(0.94, 1.06)		0.22		
CKL21	0.798	0.100	0.91	(0.88, 1.12)	0.92	(0.92, 1.08)			0.80	
			Transition Point				-0.19	0.21	0.98	2.28

Source: Authors' work

Figure 1. Therefore, it can be concluded that the number and algebra assessment tool is appropriate in terms of the data.

Next, the findings with regard to the measurement and geometry content constituent indicated that the item difficulties varied from -1.332 logits (*SE* = 0.109) to +0.935 logits (*SE* = 0.105) and -1.172 logits (*SE* = 0.108) to 0.870 logits (*SE* = 0.106) in the respective MME and CKL dimensions. Nevertheless, the findings in terms of the OUTFIT MNSQ and the INFIT MNSQ values were between 0.83–1.25 and 0.87–1.18. Consequently, they have achieved the criteria for determining the suitability of the digital learning platform in terms of the measurement and geometry content constituent (Adam & Khoo, 1996; Wilson et al., 2006), as demonstrated in Figure 2. Therefore, the researchers concluded that the measurement and geometry assessment tool is appropriate for the data.

The final findings of item fit relating to statistics and probability (17 items) showed

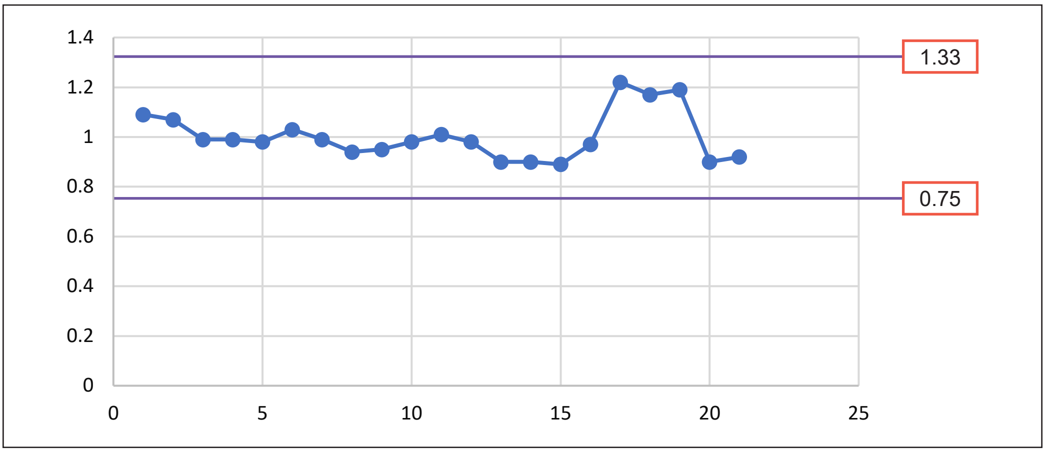

Figure 1. Item fit graph of INFIT MNSQ values of 21 items in number and algebra
Source: Authors' work

Table 7
Findings of item fit analysis for measurement and geometry constituent

Item	Difficulty	SE	OUTFIT		INFIT		Item score threshold			
			MNSQ	CI	MNSQ	CI	1	2	3	4
MME1	-0.173	0.098	0.86	(0.88, 1.12)	0.90	(0.93, 1.07)		-0.17		
MME2	-0.952	0.103	0.80	(0.88, 1.12)	0.91	(0.91, 1.09)	-0.95			
MME3	0.392	0.100	1.14	(0.88, 1.12)	1.03	(0.92, 1.08)			0.39	
MME6	0.452	0.100	0.87	(0.88, 1.12)	0.89	(0.92, 1.08)			0.45	
MME15	-0.067	0.098	1.16	(0.88, 1.12)	1.11	(0.92, 1.08)		-0.07		
MME16	0.935	0.105	1.05	(0.88, 1.12)	0.94	(0.90, 1.10)				0.94
MME17	0.719	0.103	1.31	(0.88, 1.12)	1.17	(0.91, 1.09)				0.72
MME18	-1.332	0.109	1.27	(0.88, 1.12)	1.10	(0.90, 1.10)	-1.34			
MME19	-0.703	0.101	0.90	(0.88, 1.12)	0.94	(0.92, 1.08)	-0.70			
MME20	0.166	0.099	1.02	(0.88, 1.12)	1.01	(0.92, 1.08)		0.16		
Transition Point							-1.00	-0.03	0.42	0.83
CKL4	-0.945	0.105	0.82	(0.88, 1.12)	0.94	(0.91, 1.09)	-0.95			
CKL5	0.175	0.101	0.95	(0.88, 1.12)	0.96	(0.92, 1.08)			0.17	
CKL7	0.605	0.104	1.13	(0.88, 1.12)	1.04	(0.91, 1.09)				0.60
CKL8	0.155	0.101	1.15	(0.88, 1.12)	1.12	(0.92, 1.08)			0.16	
CKL9	-1.080	0.107	1.13	(0.88, 1.12)	1.01	(0.90, 1.10)	-1.08			
CKL10	0.870	0.106	1.34	(0.88, 1.12)	1.24	(0.90, 1.10)				0.87
CKL11	-1.149	0.108	0.77	(0.88, 1.12)	0.91	(0.90, 1.10)	-1.15			
CKL12	-1.172	0.108	0.70	(0.88, 1.12)	0.85	(0.90, 1.10)	-1.17			
CKL13	0.802	0.106	1.04	(0.88, 1.12)	0.98	(0.90, 1.10)				0.80
CKL14	-0.508	0.102	0.82	(0.88, 1.12)	0.88	(0.92, 1.08)		-0.51		
Transition Point							-1.09	-0.51	0.17	0.76

Source: Authors' work

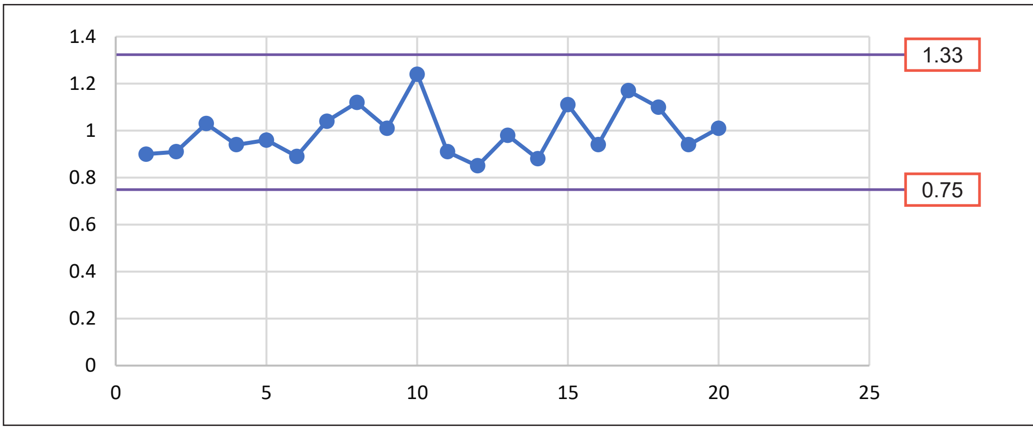

Figure 2. Item fit graph of INFIT MNSQ values of 20 items in measurement and geometry
Source: Authors' work

that the item difficulties fluctuated from –2.853 logits (*SE* = 0.158) to +0.608 logits (*SE* = 0.104) for the MME dimension and from -0.516 logits (*SE* = 0.103) to +3.158 logits (*SE* = 0.183) for the CKL dimension. In addition, the findings with regard to both OUTFIT MNSQ and INFIT MNSQ values were between 0.83–1.25 and 0.87–1.18 and have therefore achieved the criteria for determining the suitability of the digital learning platform in terms of the statistics and probability content constituent (Adam & Khoo, 1996; Wilson et al., 2006) as verified in Figure 3. Therefore, it can be concluded that the statistics and probability assessment tool is in an acceptable range.

Evaluation of Degrees of Student Mathematical Competency Using Wright Map

The researchers continued by examining the structural validity of the construct map

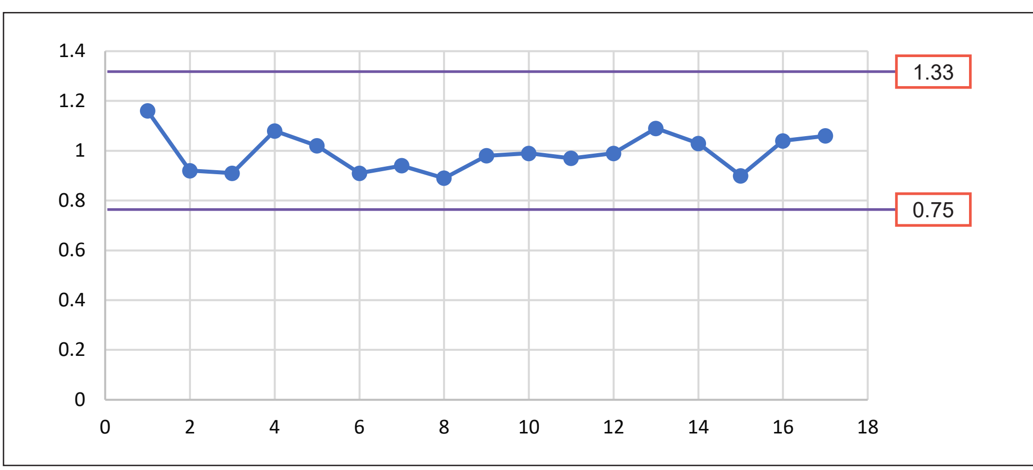

Figure 3. Item fit graph of INFIT MNSQ values of 17 items in statistics and probability
Source: Authors' work

Table 8
Findings of item fit analysis for statistics and probability constituent

Item	Difficulty	SE	OUTFIT		INFIT		Item score threshold			
			MNSQ	CI	MNSQ	CI	1	2	3	4
MME3	-1.196	0.109	0.79	(0.88, 1.12)	0.91	(0.90, 1.10)		-1.20		
MME7	-1.713	0.119	1.01	(0.88, 1.12)	0.94	(0.87, 1.13)		-1.71		
MME8	-2.853	0.158	0.71	(0.88, 1.12)	0.89	(0.78, 1.22)	-2.85			
MME9	-0.209	0.102	0.99	(0.88, 1.12)	0.98	(0.92, 1.08)			-0.21	
MME10	-0.406	0.102	1.02	(0.88, 1.12)	0.99	(0.92, 1.08)			-0.41	
MME11	-0.516	0.103	0.95	(0.88, 1.12)	0.97	(0.92, 1.08)			-0.52	
MME12	0.608	0.104	1.01	(0.88, 1.12)	0.99	(0.91, 1.09)				0.61
MME13	-0.146	0.102	1.12	(0.88, 1.12)	1.09	(0.92, 1.08)			-0.16	
Transition Point							-2.85	-1.46	-0.33	0.61
CKL1	0.105	0.102	1.21	(0.88, 1.12)	1.16	(0.92, 1.08)		0.11		
CKL2	-0.479	0.103	0.86	(0.88, 1.12)	0.92	(0.92, 1.08)	-0.49			
CKL4	3.158	0.183	2.33	(0.88, 1.12)	1.08	(0.74, 1.26)				3.16
CKL5	-0.516	0.103	1.00	(0.88, 1.12)	1.02	(0.92, 1.08)	-0.52			
CKL6	0.303	0.102	0.89	(0.88, 1.12)	0.91	(0.92, 1.08)		0.30		
CKL14	0.937	0.108	1.12	(0.88, 1.12)	1.03	(0.90, 1.10)			0.94	
CKL15	0.116	0.102	0.89	(0.88, 1.12)	0.90	(0.92, 1.08)		0.12		
CKL16	-0.132	0.102	1.07	(0.88, 1.12)	1.04	(0.92, 1.08)		-0.13		
CKL17	0.387	0.103	1.07	(0.88, 1.12)	1.06	(0.91, 1.09)		0.39		
Transition Point							-0.51	0.16	0.94	3.16

Source: Authors' work

and the criterion area of the Wright map to verify the transition points. The transition points were calculated from the mean of the item thresholds in each degree for each dimension, as demonstrated in Tables 6, 7, and 8.

Degrees of Student Mathematical Competency Using the Wright Map for the Number and Algebra Content Constituent

Table 6 shows the difficulty and threshold values of 21 items, 11 in the MME dimension and 10 in the CKL dimension. Each dimension has four degrees of mathematical competency. The four degrees of competency in terms of the MME dimension for the number and algebra content constituent are: Threshold 1 consists of items 5, 10, 11 with threshold values of -066, -0.28, and -0.67, respectively; Threshold 2 consists of item 3 only with a threshold value of 0.13; Threshold 3 consists of item 1, 2, 4, and 9 with threshold values of 0.88, 0.54, 0.76, 0.66, correspondingly, and Threshold 4 consists of item 6, 7, and 8 with threshold values 1.23, 1.22, 1.03, respectively. Conversely, the four degrees of competency of the CKL dimension for the number and algebra content constituent are: Threshold 1 consists of item 12 with a threshold value of -0.19; Threshold 2 consists of items 16 and 20 with threshold values of 0.20 and 0.22; Threshold 3 consists of item 13, 14, 15, 18, 19, and 21 with threshold values 0.96, 0.73, 1.02, 1.06, 1.33, and 0.80, respectively, and Threshold 4 only has item 17 with a threshold value of 2.28.

Degrees of Student Mathematical Competency Using the Wright Map for the Measurement and Geometry Content Constituent

Table 7 shows the difficulty and threshold values of 20 items. Each dimension has ten items as well as four degrees of mathematical competency. The four degrees of competency of the MAP dimension for the measurement and geometry content constituent are: Threshold 1 consists of items 2, 18, 19 with threshold values of -095, -1.34, and -0.70, respectively; Threshold 2 consists of items 1, 15, and 20 with threshold values of -0.17, -0.07, and 0.16 respectively; Threshold 3 consists of items 3 and 6 with threshold values as 0.39 and 0.45, and Threshold 4 consists of items 16 and 17 with threshold values 0.94 and 0.72, respectively. In addition, the four degrees of competency of the CKL dimension for the measurement and geometry content constituent are: Threshold 1 consists of items 4, 9, 11, and 12 with threshold values of -0.95, -1.08, -1.15, and -1.17, respectively; Threshold 2 consists of item 14 only, with a threshold value of -0.51; Threshold 3 consists of items 5 and 8 with threshold values 0.17 and 0.16, respectively, and Threshold 4 consists of items 7, 10, and 13 with threshold values of 0.60, 0.87, and 0.80, respectively.

Degrees of Student Mathematical Competency Using the Wright Map for the Statistics and Probability Content Constituent

Table 8 shows the difficulty and threshold values of 17 items, namely eight items in the MME dimension and nine in the CKL dimension. Each dimension has four degrees of mathematical competency. The four degrees of competency of the MME dimension for the statistics and probability content constituent are: Threshold 1 consists of item 8 only with a threshold value of -0.28; Threshold 2 consists of items 3 and 7 with threshold values of -1.20 and -1.71 respectively; Threshold 3 consists of item 9, 10, 11, and 13 with threshold values as -0.21, -0.41, -0.52, -0.16, respectively, and Threshold 4 consists of item 12 with a threshold value of 0.61. In contrast, the four degrees of competency of the CKL dimension for statistics and probability content constituent are: Threshold 1 consists of item 2 and item 5 with threshold values of -0.49 and -0.52, respectively; Threshold 2 consists of items 1, 6, 15, 16, and 17 with threshold values of 0.11, 0.30, 0.12, -0.13, and 0.39, respectively; Threshold 3 consists of only item 14 with a threshold value 0.94, and Threshold 4 has item 4 with a threshold value of 3.16.

Degrees of Student Mathematical Competency Using a Multidimensional Test Response Model

The mean threshold of each dimension of the degree of mathematical competency for the three studied content constituents was applied to create a standardized mathematical competency measurement model. The transition point was calculated from the mean of the item thresholds in each degree of the dimension, as elucidated in Tables 6, 7, and 8 for the respective number and algebra content constituent, the measurement and geometry content constituent, and the statistics and probability content constituent. The researchers then created measurement standards by taking into account the transition in conjunction with the criteria area on the Wright map for every degree of mathematical competency, as shown in Figures 4, 5, and 6. The mean threshold is determined with regard to the equivalent degree of mathematical competency for every content constituent of the two dimensions of mathematics. The researchers made a comparison of students and items by using the Wright map to verify the transition point through the criteria area setting (Lunz, 2010) to understand the measurement of mathematical competency specifically. Based on this line of reasoning, the benchmarks for diagnosing students' mathematical competency levels in every dimension would follow the intersection point to cluster degrees of student mathematical competency in accordance with the categorization recommended by Junpeng et al. (2019). Table 9 shows the construct map of the MME and CKL dimensions.

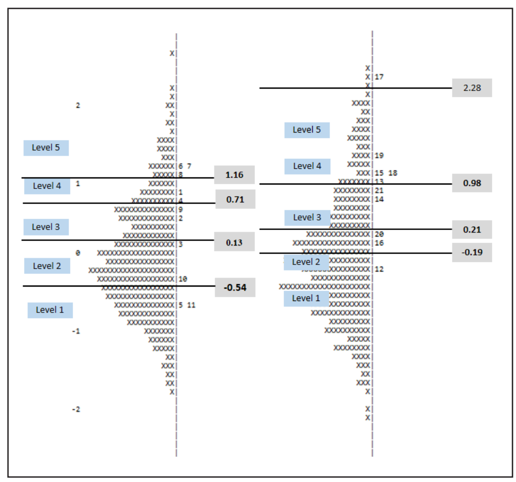

Figure 4. Wright map indicates the transition points of MME and CKL dimensions for number and algebra content constituent
Source: Authors' work

Table 9
Construct maps of the MME and CKL dimensions of mathematical competence standards

Dimension Level	Learning Progress Level	Diagnostic Descriptions
MME Degree 5	Strategic/extended thinking	Students can solve a complex problem using multiple steps. The procedure is clearly described and illustrated in various methods that can be utilized to a higher degree.
MME Degree 4	Simple skills and concepts	Students can solve a complex problem using more than one step. The procedure involves applying principles and theories, but the answer is not matched due to miscalculation.
MME Degree 3	Basic memory and reproduction	Students can use their basic understanding of mathematical procedures to find the answer. However, the answer is incomplete due to a lack of application.

Table 9 *(continue)*

Dimension Level	Learning Progress Level	Diagnostic Descriptions
MME Degree 2	Unrecalled memory	Students can use their understanding of simple mathematical procedures to solve the problem. However, the answer reflects that the student is unable to remember important content as a basis for solving the problem.
MME Degree 1	Non-response/ irrelevance	Students cannot use proper mathematical procedures to obtain the answer.
CKL Degree 5	Extended abstract structure	Students can relate concepts, summarize references as abstract knowledge, and use them to conclusions.
CKL Degree 4	Relation structure	Students can connect complex concepts, describe each part, and relate to problem situations but cannot summarize as an abstract body of knowledge to analyze or integrate the concepts.
CKL Degree 3	Multi-structure	Students can connect simple concepts but are unable to identify what they have learned in the form of memory to solve problems.
CKL Degree 2	Uni-structure	Students can solve an example-like problem without adding conditions or concepts. However, they often misunderstand concepts and lack skills in interpreting information.
CKL Degree 1	Pre-structure	Students lack the skills to interpret problem situations and are unable to form concepts.

Source: Authors' work

Degrees of Student Mathematical Competency Using a Multidimensional Test Response Model for the Number and Algebra Content Constituent

Based on the determination of the cut-off point in measuring the mathematical competencies of the students' test in terms of the number and algebra content constituent, the findings indicated that the transition point could be allocated into four cut-off points of five degrees each in ascending order. For instance, the intersections of the MME dimension were discovered from Degrees 1 to 2, Degrees 2 to 3, Degrees 3 to 4, and Degrees 4 to 5 as -0.54, 0.13, 0.71, and 2.43, respectively. Conversely, the intersections of the CKL dimension were recognized from Degrees 1 to 2, Degrees 2 to 3, Degrees 3 to 4, and Degrees 4 to 5 as -0.19, 0.21, 0.98, and 2.28, respectively. Figure 4 shows the transition point in every dimension from the Wright map with regard to the number and algebra content constituent.

The researchers then used the measurement criterion findings from the Wright map to design the specification adjustments for a mathematical competency measurement model for the number and algebra content constituent. Thus, the researchers determined five score ranges, which were transformed from evaluation mathematical competency parameters into scale scores and raw scores in that order. Table 10 demonstrates that those students who achieve their logits smaller than -0.54 and -0.19 in the MME and CKL dimensions, respectively, are

Table 10
Findings of determination of mathematical competence standards for the number and algebra content constituent

Dimension	Intersection θ	θ range	Scale scores	Raw scores
MME Degree 5	1.16	>1.16	>61.60	8–11
MME Degree 4	0.71	0.71<θ<1.16	57.10–61.59	7
MME Degree 3	0.13	0.13<θ<0.70	51.30–57.09	5–6
MME Degree 2	-0.54	0.54<θ<0.12	44.60–51.49	4
MME Degree 1	-	<0.54	<44.60	1–3
CKL Degree 5	2.28	>2.28	>72.80	8–10
CKL Degree 4	0.98	0.98<θ<2.28	59.80–72.80	6–7
CKL Degree 3	0.21	0.21<θ<0.97	52.10–59.79	4–5
CKL Degree 2	-0.19	-0.19<θ<0.20	39.10–52.09	3
CKL Degree 1	-	<-0.19	<39.10	0–2

Source: Authors' work

identified as possessing the lowest degree of mathematical competency. Likewise, if their logits are greater than 1.16 and 2.28 with regard to the MME and CKL dimensions, respectively, those students are identified as achieving the highest degree of mathematical competency.

Degrees of Student Mathematical Competency Using a Multidimensional Test Response Model for the Measurement and Geometry Content Constituent

According to the determination of the cut-off point in measuring the mathematical competencies of the students' test in the measurement and geometry content constituent, the findings indicated that the transition point could be allocated into four cut-off points of five degrees in ascending order. For instance, the intersections of MME dimensions were discovered from Degrees 1 to 2, Degrees 2 to 3, Degrees 3 to 4, and Degrees 4 to 5 as -1.00, -0.03, 0.42, and 0.83, respectively. On the other hand, the intersections of the CKL dimension were identified from Degrees 1 to 2, Degrees 2 to 3, Degrees 3 to 4, and Degrees 4 to 5 as -1.09, -0.51, 0.17, and 0.76, respectively. Figure 5 shows the transition point in

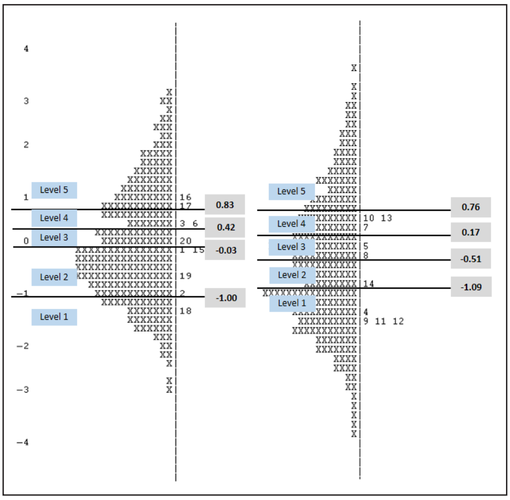

Figure 5. Wright map indicates the transition points of MME and CKL dimensions for measurement and geometry content constituent
Source: Authors' work

every dimension of the Wright map for the measurement and geometry content constituent.

The researchers then used the measurement criterion findings from the Wright map to design the specification adjustments for a mathematical competency measurement model for the measurement and geometry content constituent. Thus, the researchers identified five score ranges, which are transformed from evaluation mathematical competency parameters into scale scores and raw scores correspondingly. Table 11 reveals that those students who attain logits lower than -1.00 and -1.09 in the MME and CKL dimensions, respectively, are identified as possessing the lowest degree of mathematical competency. Similarly, if their logits are greater than 0.83 and 0.76 with regard to the MME and CKL dimensions, those students are identified as possessing the highest degree of mathematical competency.

Degrees of Student Mathematical Competency Using a Multidimensional Test Response Model for the Statistics and Probability Content Constituent

As stated by the determination of the cut-off point in gauging the mathematical competencies of the students' test in terms of the statistics and probability content constituent, the findings indicated that the transition point could be allotted into four cut-off points of five degrees in ascending order. For occurrence, the intersections of the MME dimension were discovered from Degrees 1 to 2, Degrees 2 to 3, Degrees 3 to 4, and Degrees 4 to 5 as -2.85, -1.46, -0.33, and 0.61, respectively. Conversely, the intersections of the CKL dimension were identified from Degree 1 to 2, Degree 2 to 3, Degree 3 to 4, and Degree 4 to 5 as -0.51, 0.16, 0.94, and 3.16, respectively. Figure 6 shows the transition point in every dimension from the Wright map with regard to the statistics and probability content constituent.

Table 11
Findings with regard to the determination of mathematical competence standards for the measurement and geometry content constituent

Dimension	Intersection θ	θ range	Scale scores	Raw scores
MME Degree 5	0.83	>0.83	>58.30	8–10
MME Degree 4	0.42	$0.42<\theta<0.83$	54.20–58.29	7
MME Degree 3	-0.03	$-0.03<\theta<0.41$	49.70–54.19	4–6
MME Degree 2	-1.00	$-1.00<\theta<-0.04$	40.00–49.69	2–3
MME Degree 1	-	<-1.00	<40.00	0–1
CKL Degree 5	0.76	>0.76	>57.60	8–10
CKL Degree 4	0.17	$0.17<\theta<0.76$	51.70–57.59	7
CKL Degree 3	-0.51	$-0.51<\theta<0.16$	44.90–51.69	4–6
CKL Degree 2	-1.09	$-1.09<\theta<-0.52$	39.10–44.89	2–3
CKL Degree 1	-	<-1.09	<39.10	0–1

Source: Authors' work

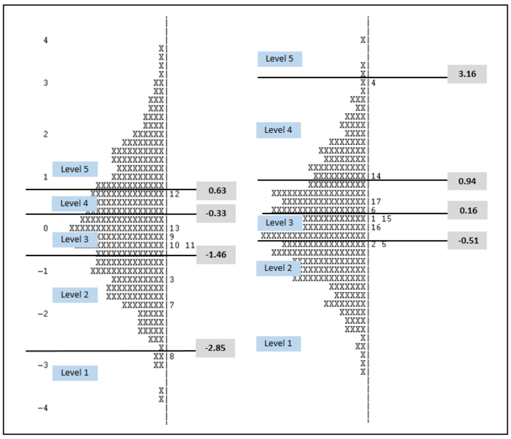

Figure 6. Wright map indicates the transition points of MME and CKL dimensions for statistics and probability content constituent
Source: Authors' work

The researchers then used the measurement criterion findings from the Wright map to identify the specification adjustments for a mathematical competency measurement model for the statistics and probability content constituent. Consequently, the researchers determined five score ranges, which were transformed from evaluation mathematical competency parameters into scale scores and raw scores in that order. Table 12 indicates that those students who achieved logits lower than -2.85 and -0.51 in MME and CKL dimensions are separately deemed to possess the lowest degree of mathematical competency. Correspondingly, those students possess the highest degree of mathematical competency if their logits are greater than 0.63 and 3.16 in the MME and CKL dimensions.

Findings of Heuristic Evaluation

The heuristic evaluation findings are based on the quality of the real-time digital learning platform in terms of its usefulness, feasibility, and accuracy, as reported by six experts. The six experts reported that the real-time digital learning platform for diagnosing the degree of student mathematical competency in number and algebra, measurement and geometry, and statistics and probability content constituents was highly applicable in terms of its usefulness, feasibility, and

Table 12
Findings of determination of mathematical competence standards for the statistics and probability content constituent

Dimension	Intersection θ	θ range	Scale scores	Raw scores
MME Degree 5	0.63	>0.63	>56.30	7–8
MME Degree 4	-0.33	$-0.33<\theta<0.63$	46.70–56.29	6
MME Degree 3	-1.46	$-1.46<\theta<-0.34$	35.40–46.69	4–5
MME Degree 2	-2.85	$-2.85<\theta<-1.47$	21.50–35.39	2–3
MME Degree 1	-	<-2.85	<21.50	0–1
CKL Degree 5	3.16	>3.16	>81.60	7–9
CKL Degree 4	0.94	$0.94<\theta<3.16$	59.40–81.59	5–6
CKL Degree 3	0.16	$0.16<\theta<0.93$	51.60–59.39	3–4
CKL Degree 2	-0.51	$-0.51<\theta<0.15$	44.90–51.59	1–2
CKL Degree 1	-	<-0.51	<44.90	0

Source: Authors' work

accuracy. The highest mean score related to the usefulness of the real-time digital learning platform (mean score = 4.50, *SD* = 0.50) and applicability. The finding implies that the real-time digital learning platform can react to the requirements of students, and students' feedback can be used to diagnose their degree of mathematical competency concretely. In addition, the report the platform provides can then be utilized to prepare students to improve their learning outcomes.

It is observed with regard to the accuracy of the real-time digital learning platform, which displayed a high degree of applicability with a mean score of 4.44 and a standard deviation of 0.52. Therefore, the finding implies that the real-time digital learning platform can accurately specify the measurement objectives, the measurement process is accurate, and the feedback reports accurately match the degree of student competency. Although the feasibility aspect was found to have the lowest mean score (4.17) with a standard deviation of 0.26, it was still deemed to be most applicable. The findings imply that the real-time digital learning platform is a clearly defined method for reporting the degree of student mathematical competency. In addition, the scope of reporting content applies to a comprehensive measurement report. Finally, the overall quality of the real-time digital learning platform (mean score = 4.37; *SD* = 0.42) is consistent with current learning measurement guidelines. Table 13 illustrates the findings of the heuristic evaluation in detail.

CONCLUSION

Our findings indicate a need for mathematics teachers to respond swiftly to technology adoption by using the real-time digital learning platform for diagnosing degrees of mathematical competency with regard to seventh-grade students so that they can overcome the challenges posed by the COVID-19 pandemic. The key findings of this research relate to the quality of the real-time digital learning platform in terms of its usefulness, accuracy, and feasibility. Our findings correspond to Clark-Wilson's (2020) findings on teacher use of digital technology in mathematics learning and how this has been accomplished. Therefore, the researchers would like to suggest to the Thailand Ministry of Education that there is a need to adopt it nationwide to support student learning and foster their academic growth so that students can be assessed

Table 13
Findings of the heuristic evaluation

Quality Aspect	Mean Score	Standard Deviation	Applicability Degree
Usefulness	4.50	0.50	Most applicable
Feasibility	4.17	0.26	Most applicable
Accuracy	4.44	0.52	Most applicable
Overall	4.37	0.42	

Source: Authors' work

using an online environment that allows for automated and timely scoring. As a result, the real-time digital learning platform will allow a much faster turnaround of results, which is crucial for mathematics teachers when making instructional decisions at the individual student and instructional unit levels (Seo et al., 2021).

Implications for Theory and Practice

Existing educational theories often focus on generalized teaching methods, overlooking the diverse learning needs of individual students, especially in mathematics (Inprasitha, 2022). A real-time digital learning platform can address this gap by tailoring instructional content based on the specific competencies and learning styles of each student (Inprasitha, 2023). Besides, traditional assessment models may not effectively capture the dynamic nature of mathematical competency development. A real-time platform can incorporate continuous and adaptive assessment techniques, allowing for a more accurate and real-time evaluation of a student's mathematical proficiency.

In addition, the researchers employed by IRT in developing a real-time digital learning platform have allowed for creating adaptive assessments within a real-time digital learning platform. As students answer questions, the system can dynamically adjust the difficulty of subsequent items based on their previous responses. It ensures that the assessment is finely tuned to each student's level of competency, providing a more accurate and efficient diagnosis. Moreover, IRT can be integrated into the platform to analyze the strengths and weaknesses of individual students. Based on their responses to specific items, the system can recommend personalized learning paths, focusing on areas where the student needs improvement. This adaptive and tailored approach enhances the efficiency of the learning process. In conclusion, the digital platform can continuously monitor a student's progress over time rather than relying solely on periodic assessments, and the system can gather data from each interaction to update the estimate of the student's mathematical competency. This real-time monitoring enables timely intervention and support.

Limitations and Recommendations for Future Research

Developing a real-time digital learning platform for diagnosing degrees of mathematical competency is a complex task that involves various challenges and considerations. In other words, the effectiveness of the platform heavily relies on the quality and diversity of the data used for training and testing, which will be the limitation. Future research should focus on collecting high-quality and diverse datasets representing various mathematical competencies across different demographics.

Another limitation is that some students may have unique learning styles, and a one-size-fits-all approach might not be optimal. Therefore, future researchers are recommended to investigate methods for personalization and adaptability in the platform to cater to individual learning preferences and needs. Moreover, providing accurate real-time feedback is challenging, and there may be instances where the platform misinterprets a student's competency level. Future researchers can invest in advanced algorithms and artificial intelligence techniques to enhance the accuracy of real-time feedback, minimizing false positives and negatives.

The researchers would like to suggest that future research investigate the incorporation of various pedagogical approaches, such as inquiry-based learning or collaborative learning, to enhance the overall effectiveness of the platform. On the other hand, future research should stay updated with technological advancements, such as machine learning and artificial intelligence advancements and leverage these technologies to improve the platform's capabilities.

As never before, students with limited mathematical competencies are indicated to have underdeveloped mathematical skills. It is a formidable barrier to participation in their future learning (Michael & Ritzelda, 2021) with the use of real-world requirements with regard to the mathematics knowledge used in daily life and their future academic and economic pursuits. The real-time digital learning platform is proven to be effective in helping students acquire the fundamental mathematical competencies they need to achieve success in their current and future learning, as emphasized by previous researchers (Kantahan et al., 2020; Kesorn et al., 2020; Maisa et al., 2021). The research indicates that a real-time digital learning platform not only diagnoses degrees of mathematical competency but also provides the knowledge needed to stimulate their individual needs and the competencies required in this new normal era.

The researchers concluded by addressing these limitations and pursuing these recommendations. Future researchers can contribute to developing a more effective, inclusive, and ethically sound real-time digital learning platform for diagnosing degrees of mathematical competency.

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