An Assessment of Students' Mathematical Competency Through the Mathematics Festival's Activity

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Abstract
The purpose of this research was to explore ways in assessing students' mathematical competencies needed for the 21st-century goal. The creation of the Thailand Mathematics Festival was adapted from the original Moscow Mathematics Festival in providing various assessment activities to analyze students' mathematical competencies. The target group consisted of seventh-grade students who participated in the second Thailand Mathematics Festival 2020. The research instrument was the Olympiad activity as a part of the Mathematics Festival. This was used to collect their mathematical thinking/ideas related to mathematics contents defined by experts from the Moscow Center for Continuous Mathematical Education (MCCME, 2021) that will lead to the performance of the students' mathematical competence. Data were collected based on students' expressive ideas according to their problem-solving solutions, indicated in their worksheets. The data were analyzed by using the mathematical thinking framework of Isoda & Katagiri (2012). The findings indicated that the Mathematics Olympiad functions as a tool for assessing the mathematical competencies of seventh-grade students. The findings imply that students have the ability to exhibit their mathematical competencies through their mathematical thinking in terms of the following Mathematical idea: Idea of Sets; Units; Representation; Operation; Algorithms; Approximations; Fundamental Properties; Functional Thinking, and Idea of Expressions.

Keywords: Assessment, Mathematical Competency, Mathematics Festival

Introduction

In the 21st century, global transformations necessitate nations to prioritize workforce development and higher-order skills (Wandee et al., 2018). Educational systems must adapt to prepare individuals for rapid changes, emphasizing 21st-century skills crucial for addressing modern challenges (Jintana, 2015). Rizki and Priatna (2019) underscore the importance of mathematical literacy, aligning with competencies like critical thinking and collaboration (Berry, 2018). Effective mathematics education should shift from memorization to connected learning experiences (Lampert, 2001; NCTM, 2010). Classroom discourse activities promoting reasoning, interpretation, and collaboration are essential for students to apply mathematical concepts (Smit, 2016).

Responding to 21st-century demands, Southeast Asian countries, particularly Thailand, face a shortage of skilled labor in mathematics-related fields. Assessments like TIMSS and PISA reveal low mathematical competency among Thai students (Inprasitha, 2017). An education system aligned with 21st-century goals, focusing on practical application skills over standardized testing, is essential (Bellanca & Brandt, 2011). Thailand's participation in the Mathematical Festival showcases collaborative efforts to enhance math learning in a joyful context (Inprasitha, 2019).

The Moscow Mathematical Olympiad, held for 75 years, challenges students with diverse, difficult problems to stimulate creativity (Fedorov et al., 2011). The competition's "non-standard tasks" emphasize imagination and flexibility (Yashchenko, 2013). Mathematical Olympiads assess problem-solving abilities, focusing on clear and understandable mathematical concepts (IMO Foundation, 2015). The Olympiad incorporates "Mathematical Festival" activities, aligning with Moscow's efforts to promote cultural and mathematical understanding since 2009 (Moscow Center for Continuous Mathematical Education, 2022).

The Mathematical Festival, emphasizing mathematical thinking and joyful engagement, crucial for independent problem-solving in a changing world. The festival involves problem-solving and games, providing a positive avenue for students to experience the beauty of mathematics. This aligns with the modern educational shift towards cultivating Mathematical Thinking, particularly in connection with mathematical content, operation, algorithms, and expressions. The festival's non-standard tasks challenge students' imagination and problem-solving skills, addressing the global need for adaptable skills. Assessing students' mathematical competency during the festival reflects a departure from traditional standardized testing, emphasizing practical application skills (Bellanca & Brandt, 2011). The study aims to analyze the mathematical competency demonstrated by Thai high school students during the Mathematical Festival, using Isoda and Katagiri's framework (2012).

Methodology

The study focused on 124 seventh-grade students from 14 schools who actively participated in the second Thailand Mathematics Festival held in 2020. The research instrument chosen for this study was the Mathematics Olympiad, a key component of the festival. The selection of this instrument was grounded in its ability to elicit comprehensive responses from students, showcasing their mathematical thinking and problem-solving skills.

The mathematical contents targeted in the Olympiad were carefully curated by experts from the Moscow Center for Continuous Mathematical Education (MCCME, 2021). These

contents covered a wide spectrum of competencies, including geometric facts, decimal notation, constructive problem-solving, combinatorics, textual problem analysis, and logical reasoning. This alignment with expert-defined contents aimed to ensure that the assessment was not only meaningful but also reflective of globally acknowledged mathematical competencies.

Instruments

In this research, the researcher employed the Mathematical Festival as the primary instrument for data collection. The event, held for the second time in Thailand on December 19, 2020, at Moscow State University, Russia, has been a continuous tradition for over 30 years (since 1990). The target participants included students from 6th-grade to 1st-year high school, displaying an interest in mathematics-related fields. The festival comprised Olympiad activities, lectures for students and parents, mathematical games, mathematical cartoons, and various other activities as per the schedule.

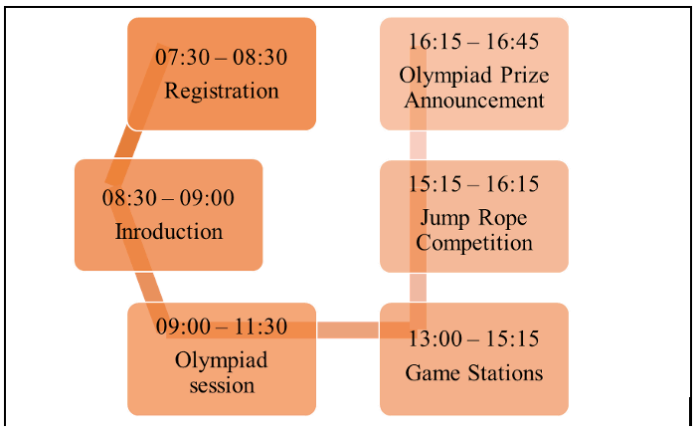


Figure 1: Mathematical Festival Schedule (December 19, 2020)

Mathematical Olympiad Activities

This comprehensive methodology ensured the quality and appropriateness of the Mathematical Festival instrument for assessing mathematical competency among Thai high school students, as shown in Figure 1.

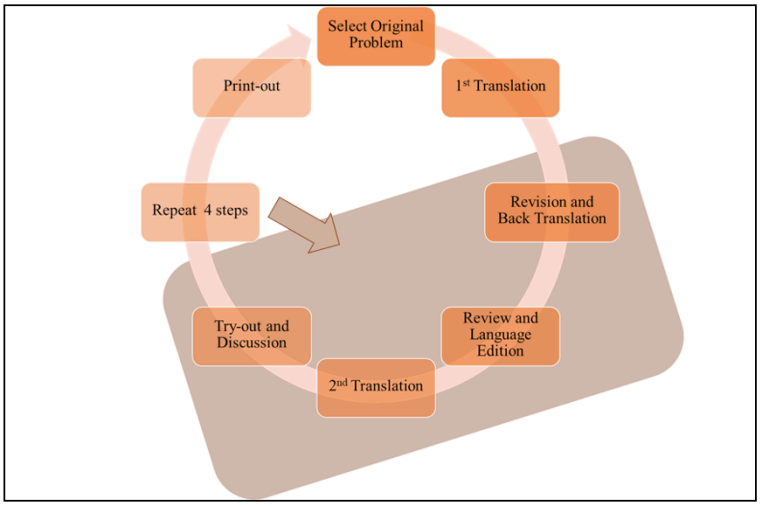
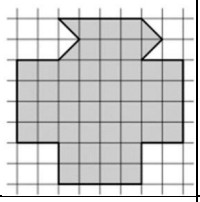


Figure 2: The Development Process of Mathematical Olympiad Problems.

1) Problem Set Development: A team of experts from Moscow Center for Continuous Mathematical Education (MCCME) selected 40 original problems used in Moscow Mathematical Olympiads.
2) Translation Process: Thai and Russian language experts translated the problem sets back and forth to ensure linguistic accuracy.
3) Thai Language Review: Experts in Thai language and mathematics from Thailand reviewed and selected 7 problems suitable for 1st-year high school students.
4) English Translation: The selected problems were translated into English by language and mathematics experts.
5) Trialing and Evaluation: The problem sets were tested by undergraduate and graduate students majoring in mathematics education, considering difficulty levels and appropriateness.
6) Collaborative Review: Faculty members and graduate students collectively reviewed the problems, focusing on language accuracy and alignment with educational objectives.
7) Final Language Check: A final check for language accuracy was performed according to the specified criteria.
8) Answer Sheet Design and Printing: The answer sheets were designed and printed for the 7 selected problems.

Problem		**Mathematical Olympiad Framework**
1.	We can easily cut a 3x3x3 cube into 27 smaller cubes by making 6 cuts. Is it possible to reduce the number of cuts by dividing the cube to get multiple smaller cubes at once in a single cut, and rearrange the cut cubes?	Use of geometric facts
2.	There are a weighing scale and three weights. If we want to use the weighing scale and weights to measure anything with a weight ranging from 1 to 10 kilograms, what should be the weight of each of the three weights? Please provide an example of the weights of the three weights.	Divisibility or properties of decimal notation
3.	Please demonstrate how to cut the following picture into 12 equal parts (the conditions for equality are that they should be identical in both shape and size). 	Constructive
4.	Nuit, the mystic writer, wants to pack 9 special animals with weights of 2, 3, 4, 5, 6, 7, 8, 9, and 10 kilograms into 3 travel bags. Each bag can only accommodate 3 animals, and the total weight must be less than 20 kilograms. If the weight of one animal is a multiple of the weight of another animal in the same bag, those two animals will fight each other. The question is, how will Nuit organize the special animals in the travel bags to prevent them from fighting?	Naive Combinatorics
5.	There are three triangular pieces of paper, placed on the table. Triangles 1 and 2 are smaller than Triangle 3. Is it possible to arrange Triangle 1 and Triangle 2 on top of Triangle 3 in a way that they completely fit, with Triangle 3 serving as the base for the other two triangles?	Use of geometric facts

Problem		Mathematical Olympiad Framework
6.	5 elephants and 7 hippos ate 11 round watermelons and 20 square watermelons for breakfast. In another group, 8 elephants and 4 hippos ate 20 round watermelons and 8 square watermelons. Each elephant ate the same number of round watermelons, and each hippo ate the same number of round watermelons. Likewise, each elephant ate the same number of square watermelons, and each hippo ate the same number of square watermelons. However, there is a type of animal that eats both round and square watermelons, while another type chooses to eat only watermelons of one shape. Which type of animal (elephant or hippo) eats only watermelons of one shape, and what is the shape of the watermelon they prefer?	Textual Problem
7.	In the magical land, there are a total of 15 cities. Each city is connected by paths to at least 7 other cities. Determine whether it is possible to drive from any one city to any other city using those paths.	Logical Tasks

Data Collection

The data for this research were collected from the Mathematical Festival, Thailand's 2nd edition, held for first-year high school students on Saturday, December 19, 2020. The assessment aimed to capture students' mathematical competencies in the form of expressing their thoughts and problem-solving methods during the festival. These data were instrumental for researchers to analyze and showcase students' mathematical competencies using the mathematical thinking framework of Isoda & Katagiri (2012), aligned with the content defined by the Moscow Center for Continuous Mathematical Education (MCCME, 2021).

4.1 Development of Data Collection Tools

A tool was created based on the structure of the Mathematical Festival's activities, modified from the original Moscow Mathematical Festival held at Moscow State University, Russia, for over 30 years. This tool facilitated the scheduling of activities for Thailand's 2nd Mathematical Festival on December 19, 2020.

4.2 Creation of Problem Sets for the Mathematical Olympiads

Problem sets for the Mathematical Olympiads were designed by translating and adapting original problem sets from the Moscow Mathematical Olympiads. These were developed by experts from the Moscow Center for Continuous Mathematical Education (MCCME) in collaboration with Thai experts. The problem sets covered six content areas to comprehensively assess students' mathematical competencies:

1) Use of geometric facts
2) Divisibility or properties of decimal notation
3) Constructive
4) Naive Combinatorics
5) Textual Problem
6) Logical Tasks

4.3 Development of Mathematical Games:

Mathematical games were created based on the original games used by MCCME in the Moscow Mathematical Festival. Trial plays were conducted to ensure a mutual understanding among the Thai organizing team. The games aimed to engage each student in various perspectives, emphasizing active participation to maximize learning outcomes.

4.4 Data Collection Process:

Data collection involved implementing the problem sets and mathematical games developed during the research tool creation process at the Mathematical Festival in Thailand, held on December 19, 2020. The participants were first-year high school students, totaling 124 individuals, as per the predetermined schedule.

Data Analysis

Qualitative data analysis was employed, utilizing information in the form of concepts, processes, or demonstrated methods for finding students' answers, as manifested on answer sheets. This analysis focused on students' explanations of concepts or methods used to arrive at solutions, aligning with mathematical thinking related to mathematical content. The content, as defined by experts from the Moscow Center for Continuous Mathematical Education (MCCME, 2021), covered six dimensions: 1) use of geometric facts, 2) division or properties of decimals, 3) constructive problem-solving, 4) combinatorics, 5) textual problems, and 6) logical problems. These dimensions were designed to assess students' mathematical competencies.

The study focused on nine mathematical ideas that represent various facets of students' mathematical competencies. These ideas are 1) Idea of Sets, 2) Units, 3) Representation, 4) Operation, 5) Algorithms, 6) Approximations, 7) Fundamental Properties, 8) Functional Thinking, and 9) Idea of Expressions. The analysis aimed to decipher students' mathematical competencies by exploring their mathematical thinking aligned with these nine concepts.

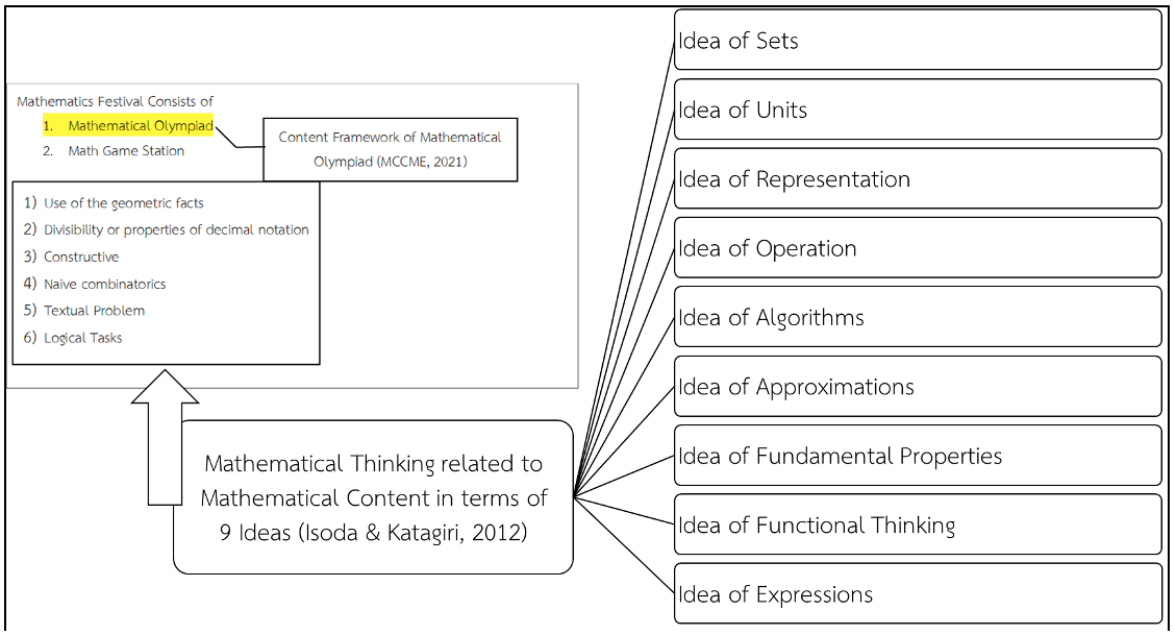


Figure 4: Data collection and analysis research framework.

In conclusion, the data analysis involved a comprehensive examination of students' responses using a qualitative approach. This approach, guided by the framework of Isoda & Katagiri (2012) and informed by the Moscow Center for Continuous Mathematical Education's content dimensions, aimed to unravel the depth of students' mathematical competencies across the identified mathematical ideas.

Results

From the analysis of mathematical competency assessments among first-year secondary school students, the conceptualization and problem-solving approaches adopted by students in tackling mathematical problems are presented. The analysis is based on the evaluation of students' mathematical competencies through the demonstration of mathematical reasoning related to the Mathematical Olympiad framework (MCCME, 2021). The framework encompasses content for each problem and is designed to cover various mathematical aspects. The analytical approach is aligned with the mathematical thinking framework proposed by Isoda & Katagiri (2012), as detailed in the following table.

Mathematical Thinking related to Mathematical Content in terms of 9 Ideas (Isoda & Katagiri, 2012)	Content Framework of Mathematical Olympiad by MCCME (2021)						
	Problem 1: Use of the geometric facts	Problem 2: Divisibility or properties of decimal notation	Problem 3: Constructive	Problem 4: Naive Combinatorics	Problem 5: Use of the geometric facts	Problem 6: Textual Problem	Problem 7: Logical Tasks
(a) Idea of Sets	✓	✓	✓	✓	✓	✓	✓
(b) Idea of Units	✓		✓			✓	
(c) Idea of Representation	✓	✓	✓	✓	✓	✓	✓
(d) Idea of Operation	✓	✓	✓	✓	✓	✓	✓
(e) Idea of Algorithms	✓	✓	✓	✓	✓	✓	✓
(f) Idea of Approximations	✓	✓				✓	
(g) Idea of Fundamental Properties	✓	✓	✓	✓	✓		✓
(h) Idea of Functional Thinking	✓			✓	✓	✓	
(i) Idea of Expressions	✓			✓	✓	✓	✓

Figure 5: Summary of mathematical ideas of students evident in the Mathematical Olympiad

Conclusion

In conclusion, this research indicated that the Mathematics Olympiad functions as a tool for assessing the mathematical competencies of seventh-grade students. The findings imply that students have the ability to exhibit their mathematical competencies through their mathematical thinking in terms of Isoda and Katagiri's (2012) conceptual framework: Idea of

Sets; Units; Representation; Operation; Algorithms; Approximations; Fundamental Properties; Functional Thinking, and Idea of Expressions.

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