



## Research Article

# DEVELOPING AND VALIDATING A RUBRIC FOR ASSESSING MIDDLE SCHOOL STUDENTS' PROBLEM-SOLVING COMPETENCY IN STATISTICS

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## ABSTRACT

*In the 2018 General Education Mathematics Curriculum, statistics is formally introduced as a new content domain spanning Grades 2 to 12. In the current educational landscape, competency-based assessment has become a central requirement, emphasizing the development of students' problem-solving competency. This study was conducted to design and validate a rubric for assessing middle school students' problem-solving competency in learning statistics, consistent with the aims of the 2018 curriculum. The rubric was constructed around four criteria intended to support formative assessment, enhance instructional practices, and foster student achievement. The study employed a mixed-method approach, including a survey of 66 mathematics teachers and a classroom experiment with 34 ninth-grade students. Findings revealed that teachers highly rated the rubric (mean scores ranging from 4.26 to 4.38,  $SD = 0.79-1.09$ ), while reliability analysis confirmed strong internal consistency (Cronbach's  $\alpha = 0.956$ ). The validation process demonstrated that the rubric is feasible for classroom use and aligned with curricular objectives. Overall, the study highlights the rubric's potential as a tool for competency-based assessment and its contribution to improving the effectiveness of teaching and learning in mathematics.*

**Keywords:** assessment rubric; GAISE II; middle school; problem-solving competency; rubric validation; statistics education

## 1. Introduction

Competency is a personal attribute formed through innate qualities and learning, enabling individuals to use knowledge, skills, interest, and willpower to complete tasks and achieve goals in specific contexts (Ministry of Education and Training [MOET], 2018a). Its assessment should be based on observable evidence through a process of defining the

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purpose, identifying evidence, selecting methods and tools, collecting and analyzing data, and drawing conclusions (MOET, 2018a).

In the 2018 General Education Mathematics Curriculum, developing problem-solving competency is a key goal (MOET, 2018b). Statistics contributes to this by helping students solve real-world problems through collecting, processing, and analyzing data, while also fostering logical and critical thinking. Therefore, clear criteria are needed to assess this competency effectively, guide teaching, support learners, and ensure transparency in assessment.

Student assessment is the process of collecting, analyzing, and interpreting information about learning to identify causes and improve teaching and learning (Nguyen et al., 2016). In classrooms, various methods are used to gather qualitative and quantitative data, helping teachers make timely instructional decisions (Nguyen et al., 2019). Hargreaves (2005) identifies two approaches: assessment-as-measurement and assessment-as-inquiry. In this context, assessment for learning helps monitor progress, guide teaching, provide feedback, and support both teachers and students.

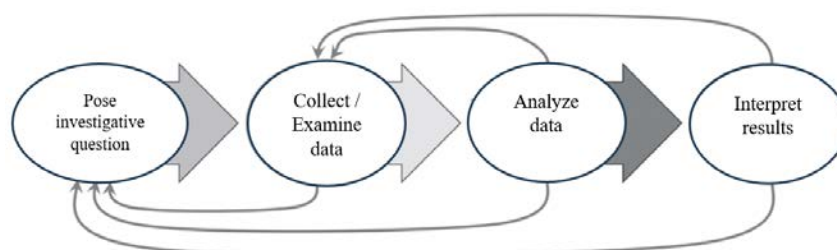
Problem-solving competency in mathematics education is a student's ability to use cognitive processes, actions, attitudes, motivation, and emotions to solve situations without ready-made procedures or standard solutions (Tran, 2019). Its assessment should consider not only outcomes but also how students identify problems, analyze data, and interpret results in the learning process.

Based on these considerations, this study aims to develop a rubric for assessing middle school students' problem-solving competency in learning statistics. The rubric is aligned with the competency-based curriculum and is intended to support formative assessment while ensuring objectivity, feasibility, and effectiveness in practice.

## 2. Methods

### 2.1. Indicators of students' problem-solving competency in statistics education at the secondary level

The problem-solving process, consisting of four steps, has been further clarified in GAISE II (Bargagliotti et al., 2020). The model described in Figure 1 is proposed for use in this investigation.



**Figure 1.** The Statistical Problem-Solving Process

According to the 2018 General Education Mathematics Curriculum issued by the Ministry of Education and Training, the indicators of mathematical problem-solving competency at the middle school level are reflected in the following abilities: identifying the problem that needs to be solved, determining the approach and solution to the problem, applying appropriate mathematical knowledge and skills to solve the problem, and explaining the solution that has been implemented.

According to Nguyen Loc et al. (2016), problem-solving competency comprises four components: identifying the problem, defining the problem space, planning and implementing solutions, and evaluating and reflecting on the solutions.

Watson and Callingham (2017) and Tran and Tarr (2017) argue that school statistics curricula often place greater emphasis on the final stages of statistical investigation, such as data representation and the calculation of statistical measures, while insufficient attention is given to the earlier stages, including formulating questions and collecting data.

To align with teaching practices and the previously mentioned indicators of problem-solving competency, we define problem-solving competency in secondary statistics education as comprising the following components:

(1) *Understanding the problem:* Identifying the statistical problem to be solved

Recognize the given data or information in the problem statement and identify the core statistical problem to be addressed.

Example 1: Select an appropriate type of chart to represent the information from the following statistical table: (*Exercise 11, page 117, Grade 8 Mathematics Textbook - Compulsory General Education Curriculum, Vietnam*)

Statistics on the most favorite sport of class 8B students		
Sports	Number of students	Percentage
Football	20	47%
Volleyball	7	17%
Table Tennis	7	17%
Badminton	8	19%

Understanding the Problem: The problem provides data on students' preferences for four sports: football, volleyball, table tennis, and badminton. The numbers and percentages of students choosing each sport are given. Based on this information, the task is to identify the most suitable chart type to represent the data effectively.

(2) *Designing a problem-solving strategy:* Apply appropriate mathematical knowledge and skills to solve the statistical problem.

Identify the relevant knowledge to be mobilized, and establish a clear process to solve the problem.

Example 2: A bakery owner wants to create a chart to show the number of cream cakes sold from Monday to Friday last week. The data is as follows: 45 cakes on Monday, 51 on

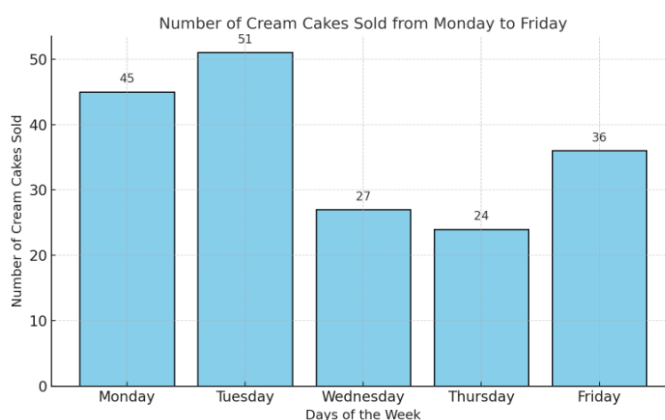
Tuesday, 27 on Wednesday, 24 on Thursday, and 36 on Friday. The task is to choose between a pictograph and a bar chart to determine which is more suitable for representing this data. Students are asked to select the more appropriate chart type and explain their reasoning based on the characteristics of the data and the clarity of representation (Nguyen et al., 2020).

The mathematical knowledge required encompasses determining the greatest common divisor, understanding the concept of perpendicular lines, and recognizing the properties of rectangles. In carrying out the plan, students are expected to select an appropriate type of chart and to justify their selection with sound reasoning. Data should be represented using two perpendicular axes: a horizontal axis and a vertical axis.

(3) *Implementing the solution:* Present the solution clearly and logically.

According to example 2, implementing the solution:

+ Since the greatest common divisor (GCD) of the data values is small relative to the differences among them, using a pictograph would require too many symbols. Therefore, a bar chart is a more appropriate way to represent the data. + The Chart:



**Figure 2.** Bar Chart of Cream Cakes Sold from Monday to Friday

(4) *Evaluating and reflecting on the solution:* Check whether the solution is complete, and think about other possible solutions.

Example 3 (*Mathematics textbook grade 8, page 106*): The first semester results of students in classes 8A and 8B are recorded in the following table:

Performance level	Excellent	Good	Satisfactory	Unsatisfactory
Class 8A	5%	45%	44%	6%
Class 8B	10%	50%	37%	3%

Select an appropriate type of chart to represent the table above.

*Evaluating and reflecting on the solution:* To assess the completeness of the chart, it is important to check whether the chart has a clear title and whether both axes are properly labeled. In addition, it is possible to explore alternative solutions. For example, the data could also be represented using two pie charts (one for each class), or a double bar chart to compare the performance distribution between the two classes.

*Evaluating and reflecting on the solution:* Check if the chart is complete by making

sure it includes a title and labels for both axes. Also, consider other possible ways to represent the data, such as using two pie charts (one for each class) or a double bar chart.

**2.2. Rubric to assess problem-solving competency**

This study reviewed rubrics developed by Toh et al. (2011), Phan (2014), Nguyen et al. (2016), and Le et al. (2022) to design a rubric to assess the problem-solving competency as follows:

*Table 1. Problem-Solving Competency Assessment Rubric*

Competency components	Student behaviors	Level			
		Level 0	Level 1	Level 2	Level 3
Exploring the problem	Identifying the statistical problem to be solved	Unable to identify the statistical problem to be solved.	Identifies only part of the statistical problem to be solved.	Identifies the statistical problem with minor errors or omissions.	Accurately and completely identifies the statistical problem to be solved.
Designing a solution strategy	Applies appropriate mathematical knowledge and demonstrates a clear strategy to solve the statistical problem.	Does not demonstrate the necessary knowledge or a strategy to solve the problem.	Demonstrates only a small part of the required knowledge and solution strategy to solve the problem.	Demonstrates the required knowledge and solution strategy with minor errors or omissions.	Demonstrates complete and accurate knowledge and an appropriate solution strategy to solve the problem.
Implementing the solution	Presenting the Solution	Does not present a solution or presents an incorrect solution.	Presents an incomplete solution that lacks coherence and logical reasoning.	Presents a solution that is somewhat lacking in coherence and logical structure.	Presents a complete and accurate solution with coherent and logical reasoning.
Evaluating and reflecting on the solution	Reviews the completeness of the solution and identifies alternative solutions.	The student does not complete the solution and does not identify any alternative solutions.	The student attempts to complete the solution and identify alternative solutions, but only partially corrects.	The student completes the solution and identifies alternative solutions, with minor errors or omissions.	The student completes the solution and accurately identifies alternative solutions.

Table 2 presents the percentage of the total score allocated to each performance indicator across proficiency levels based on the rubric.

**Table 2.** Distribution of Total Score Percentages for Each Performance Indicator

Ordinal Number	Competency components	Student Behaviors	Level			
			Level 0 (% total score)	Level 1 (% total score)	Level 2 (% total score)	Level 3 (% total score)
1	Exploring the problem	Identifying the statistical problem to be solved	0%	8%	16%	25%
2	Designing a solution strategy	Applies appropriate mathematical knowledge and demonstrates a clear strategy to solve the statistical problem.	0%	8%	16%	25%
3	Implementing the solution	Presenting the Solution	0%	8%	16%	25%
4	Evaluating and reflecting on the solution	Reviews the completeness of the solution and identifies alternative solutions.	0%	8%	16%	25%
<b>Total</b>			<b>0%</b>	<b>32%</b>	<b>64%</b>	<b>100%</b>

**Example 4:** The following table presents the number of pairs of sports shoes sold in the first quarter of 2022 by two retail stores.

Month	1	2	3
Store 1	25	23	24
Store 2	35	37	36

Select an appropriate chart and draw it to represent the data in the above table.

Below is the assessment rubric for students’ problem-solving competency in learning statistics (Table 3):

**Table 3.** Assessment of Students’ Problem-Solving Competency in Learning Statistics

The structure of problem-solving competency in learning statistics	Evaluation criteria	Assessment content	Assessment	
			Level	Content
1. Exploring the problem	Identifying the statistical problem to be solved	<i>The given data is:</i> - Store 1: Sold 25 pairs in January, 23 pairs in February, and 24 pairs in March. - Store 2: Sold 35 pairs in January, 37 pairs in February, and 36 pairs in March. <i>Problem to be solved:</i> - Choose an appropriate chart to represent the data; draw a chart to illustrate the data in the statistical table.	3	<b>Fully expresses all 3 aspects.</b>
			2	<b>Expresses 2 out of 3 aspects.</b>
			1	<b>Expresses 1 out of 3 aspects.</b>
			0	<b>Incorrect or fails to express any aspect.</b>

<p>2. Designing a solution strategy</p>	<p>Applies appropriate mathematical knowledge and demonstrates a clear strategy to solve the statistical problem.</p>	<p><i>Mathematical knowledge required to be mobilized:</i>                  - Two perpendicular lines; two rectangles.  <i>Solution strategy</i>                  - Choose an appropriate chart.                  - Represent the data on two perpendicular axes: a horizontal and a vertical axis.</p>	<p>3 2 1 0</p>	<p><b>Fully expresses all 3 aspects.</b>  <b>Expresses 2 out of 3 aspects.</b>  <b>Expresses 1 out of 3 aspects.</b>  <b>Incorrect or fails to express any aspect.</b></p>
<p>3. Implementing the solution</p>	<p>Presenting the solution</p>	<p>- A double bar chart is appropriate for representing the data.                  - Accurately divide the data across the horizontal and vertical axes.                  - The bar chart for store 1 and store 2 must be precise.                  (See figure 3)</p>	<p>3 2 1 0</p>	<p><b>Completed all 3 components.</b>  <b>Completed 2 out of 3 components.</b>  <b>Completed 1 out of 3 components.</b>  <b>Incorrect or completed none of the components.</b></p>
<p>4. Evaluating and reflecting on the solution</p>	<p>Reviews the completeness of the solution and identifies alternative solutions.</p>	<p>Complete the chart:                  - Title the chart and label the axes.                  - Add a legend.                  Alternative solution:                  - Two line charts can also be used.</p>	<p>3 2 1 0</p>	<p><b>Completed all 3 components.</b>  <b>Completed 2 out of 3 components.</b>  <b>Completed 1 out of 3 components.</b>  <b>Incorrect or completed none of the components.</b></p>

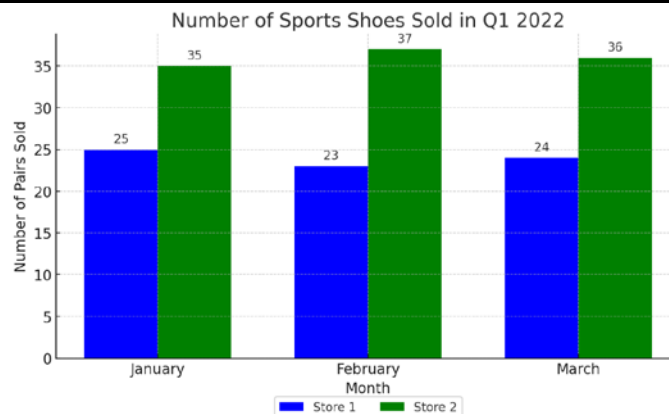


Figure 3. the Number of Sports Shoes Sold

**2.3. Teacher survey on the assessment rubric**

*2.3.1. Scope, location, method, and purpose of the survey*

To examine the feasibility and relevance of the rubric, we conducted a survey on teachers’ perceptions of the rubric. A questionnaire (see Appendix) consisting of two parts was used. Part 1 evaluated each criterion in the rubric through Questions 1–7, rated on a 5-point Likert scale (1 = Strongly disagree to 5 = Strongly agree). Part 2 included open-ended Questions 8–10, which required short written responses. A total of 66 mathematics teachers from middle schools and high schools joined the study. They were teachers in Bac Lieu Province: Bac Lieu City, Gia Rai Town, Vinh Loi District, Hoa Binh District, Phuoc Long District, Hong Dan District, and Dong Hai District. Several teachers were from Soc Trang and Dong Thap Provinces. Teachers participated voluntarily and completed a structured questionnaire administered through an online Google Form.

*2.3.2. Survey Results and Discussion*

Most of the teachers who participated in the survey held a Bachelor’s degree (92.4%). Four teachers (approximately 6.1%) had a Master’s degree, while one teacher (approximately 1.5%) held only diplomas. The gender and sampling regions were balanced in terms of participant numbers. The majority of teachers (86.4%) had more than 10 years of teaching experience.

**Table 4. Characteristics of the Sample**

Category	Sub-category	Number	Percentage
Gender	Male	33	50%
	Female	33	50%
Years of teaching experience	10 years or less	9	13.6%
	More than 10 years	57	86.4%
Region	Urban area (town/municipality/city center)	33	50%
	Suburban area	33	50%

The survey data were analyzed using SPSS (Version 20). The 5-level Likert scale was treated as a ratio scale, enabling the calculation of parameters such as the mean and standard deviation. Mean scores were interpreted using the following criteria: 1.00–1.80 = Strongly disagree; 1.81–2.60 = Disagree; 2.61–3.40 = Neutral; 3.41–4.20 = Agree; and 4.21–5.00 = Strongly agree (Hoang & Chu, 2006).

**Table 5. Teachers’ Awareness and Understanding of Evaluation Criteria**

No.	Opinion	Mean	SD
1	Q1: The criterion “Identifying the statistical problem to be solved” is appropriate and clearly stated.	4.27	1.09
2	Q2: The criterion “Using mathematical knowledge and demonstrating a solution strategy” is reasonable.	4.26	1.00
3	Q3: The criterion “Presenting the solution” effectively assesses students’ competency.	4.33	0.79
4	Q4: The criterion “Evaluating and reflecting on the solution” encourages critical thinking.	4.32	0.83
5	Q5: The scoring method using a 0–3 scale (based on the number of elements achieved) is appropriate and easy to apply.	4.38	0.82
6	Q6: The illustrative examples in the rubric are clear and relevant to actual teaching practice.	4.32	0.84
7	Q7: The rubric can be effectively applied in middle school statistics lessons.	4.36	0.80

The survey results indicate that teachers highly appreciated the clarity, relevance, and feasibility of the evaluation criteria. Most of the criteria received average scores above 4.26, demonstrating that teachers strongly agreed with their effectiveness in the context of middle school education.

Additionally, open-ended responses from 41 out of 66 participants revealed that the majority did not suggest any modifications to the criteria. Only a few constructive suggestions were made, such as increasing flexibility, encouraging self-assessment, or adapting the criteria to specific problem contexts.

With respect to implementation challenges, more than 60% of respondents indicated that they encountered no significant obstacles. The difficulties that were reported were primarily personal or contextual in nature, including time constraints and challenges related to assigning scores.

**2.4. Applying the rubric to assess student work**

After developing the assessment scale for problem-solving competency in statistics education, we conducted an experimental implementation with class 9/3 (34 students) at Bac Lieu high school on November 30, 2024. At that time, the 9th-grade students had not yet studied the Statistics unit. The assessment content was derived from knowledge taught in Grade 8, specifically the topic “Selecting appropriate chart types to represent data.” As this was the class I was directly responsible for teaching, it was convenient to conduct the trial within this context. The student assessment task was Example 4, as mentioned in Section 2.2. The number of students achieving each performance level is summarized as follows:

*Table 6. Number of Students Achieving Each Performance Level*

The structure of problem-solving competency in learning statistics	Evaluation criteria	Level			
		0	1	2	3
1. Exploring the problem	Identifying the statistical problem to be solved	2		16	16
2. Designing a solution strategy	Applies appropriate mathematical knowledge and demonstrates a clear strategy to solve the statistical problem.	2		12	20
3. Implementing the solution	Implementing the Solution	2		16	16
4. Evaluating and reflecting on the solution	Reviews the completeness of the solution and identifies alternative solutions.	2	12	20	

The experimental results from class 9/3 indicate that the majority of students attained Level 2 or Level 3 across all four criteria used to evaluate their problem-solving competency in statistics education. For the three criteria-“Identifying the statistical problem to be solved,” “Applying mathematical knowledge and demonstrating a strategy to solve the statistical problem,” and “Presenting the solution,” most students (32 out of 34) reached levels 2 and 3, respectively. This indicates that students have begun to develop essential

skills such as problem identification, planning, and solution presentation. However, for the criterion “Reflecting on the completeness of the solution and considering alternative approaches,” although many students still performed well, there was a noticeable disparity in competency, as no student reached level 3. This suggests that the skills of evaluating and reflecting on solutions need further reinforcement during instruction to help students develop a more comprehensive problem-solving competency. An example of a student’s work:

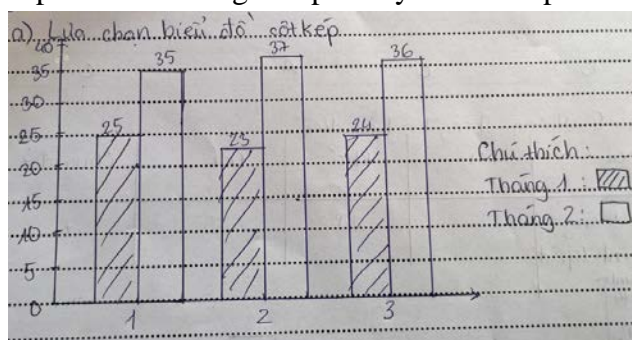


Figure 5. Student Work in Example 4

*Exploring the problem:* The student correctly represented the data provided in the problem: - Store 1: 25 pairs sold in January, 23 in February, and 24 in March; - Store 2: 35 pairs sold in January, 37 in February, and 36 in March. The student identified the problem to be solved: choosing an appropriate chart to represent the data. Thus, for this criterion, the student achieved level 3.

*In designing a solution strategy,* the student demonstrated the application of relevant mathematical knowledge, including the use of two perpendicular lines and two rectangles. The student adopted a problem-solving strategy by selecting a double bar chart to represent the data on two perpendicular axes (horizontal and vertical). Accordingly, the student was assessed at level 3 for this criterion.

*In implementing the solution,* the students successfully constructed two perpendicular axes with accurate scaling and accurately drew the bar charts for both Store 1 and Store 2. On this basis, they were evaluated at Level 3 for this criterion.

*Evaluating and reflecting on the solution:* Students were able to provide correct annotations; however, they failed to include the chart title and label the axes. Other aspects of the solution were also lacking. As a result, students only achieved Level 1 for this criterion.

Based on the criteria outlined in Table 3, students obtained 83% of the total possible points, which can be converted to a score of 8.3 out of 10.

### 3. Conclusion

This study developed and validated a rubric for assessing middle school students’ problem-solving competency in statistics, based on the 2018 General Education Mathematics Curriculum. The rubric includes four components: identifying the statistical problem, planning a solution, implementing the solution, and evaluating and reflecting on the solution, with clear criteria and performance levels. Validation through teacher surveys and classroom experiment showed that the rubric is clear, practical, and aligned with

teaching practice. The classroom results also suggest that it can distinguish different levels of student performance and support the development of statistical thinking and reasoning. However, the findings highlight the need to further strengthen students' metacognitive skills, especially in evaluating solutions and considering alternative strategies, suggesting that teaching should place greater emphasis on reflective thinking in statistical problem-solving.

In conclusion, the proposed rubric provides a valuable tool for both formative and summative assessment in statistics education, supporting the broader goals of competency-based teaching and learning. Future research should aim to refine the rubric through longitudinal studies and explore its adaptability across diverse educational contexts and interdisciplinary domains.

❖ **Conflict of Interest:** Authors have no conflict of interest to declare.

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**XÂY DỰNG THANG ĐÁNH GIÁ NĂNG LỰC GIẢI QUYẾT VẤN ĐỀ  
CỦA HỌC SINH TRONG DẠY HỌC THỐNG KÊ Ở TRUNG HỌC CƠ SỞ**  
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**TÓM TẮT**

Trong Chương trình giáo dục phổ thông môn Toán năm 2018, thống kê được chính thức đưa vào như một lĩnh vực nội dung mới, giảng dạy liên tục từ lớp 2 đến lớp 12. Trong bối cảnh giáo dục hiện nay, đánh giá theo định hướng năng lực trở thành một yêu cầu cốt lõi, nhấn mạnh việc phát triển năng lực giải quyết vấn đề của học sinh. Nghiên cứu này được thực hiện nhằm thiết kế và kiểm chứng một bảng tiêu chí (rubric) đánh giá năng lực giải quyết vấn đề của học sinh trung học cơ sở trong học tập thống kê, phù hợp với định hướng của Chương trình Toán 2018. Rubric được xây dựng dựa trên bốn tiêu chí cốt lõi, hướng tới việc hỗ trợ đánh giá quá trình, nâng cao hiệu quả dạy học và thúc đẩy thành tích học tập của học sinh. Để kiểm chứng độ tin cậy và tính khả thi, nghiên cứu sử dụng phương pháp hỗn hợp, bao gồm khảo sát 66 giáo viên toán và thực nghiệm lớp học với 34 học sinh lớp 9. Kết quả cho thấy giáo viên đánh giá rubric ở mức cao (điểm trung bình 4,26–4,38; SD = 0,79–1,09), đồng thời phân tích độ tin cậy cho thấy sự nhất quán nội tại rất cao (Cronbach's  $\alpha = 0,956$ ). Quá trình kiểm chứng khẳng định rubric có thể áp dụng hiệu quả trong thực tiễn và phù hợp với mục tiêu chương trình. Nhìn chung, nghiên cứu làm nổi bật tiềm năng của rubric như một công cụ đánh giá theo định hướng năng lực, đồng thời góp phần nâng cao hiệu quả dạy và học môn Toán.

**Từ khóa:** bảng tiêu chí đánh giá; GAISE II; trung học cơ sở; năng lực giải quyết vấn đề; kiểm chứng tiêu chí; giáo dục thống kê

**APPENDIX****Questionnaire****Part 1: Evaluation of Individual Criteria in the Rubric**

Q1: The criterion “Identifying the statistical problem to be solved” is appropriate and clearly stated.

Q2: The criterion “Using mathematical knowledge and demonstrating a solution strategy” is reasonable.

Q3: The criterion “Presenting the solution” effectively assesses students' competency.

Q4: The criterion “Evaluating and reflecting on the solution” encourages critical thinking.

Q5: The scoring method using a 0–3 scale (based on the number of elements achieved) is appropriate and easy to apply.

Q6: The illustrative examples in the rubric are clear and relevant to actual teaching practice.

Q7: The rubric can be effectively applied in middle school statistics lessons.

**Part 2: Open-Ended Feedback**

Q8: Do you think any criteria should be adjusted or added? Why?

Q9: What difficulties, if any, did you encounter when applying this rubric in your teaching?

Q10: Do you have any suggestions to improve the rubric in order to enhance its feasibility and effectiveness?