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Critical Thinking Skills In Statistics And Probability Lesson Through The Solo–Hots Based Contextualized Materials Among Grade 10 Students

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Abstract

This study investigated the development of critical thinking skills in Statistics and Probability among Grade 10 students through SOLO–HOTS based contextualized materials. It examined students' cognitive progression, engagement, understanding, influence on critical thinking, learning experiences, and areas for improvement. To obtain the results, the researcher utilized a performance task with established criteria and rubrics to determine the level of critical thinking skills demonstrated by 45 Grade 10 students, 22 male and 23 female, in solving contextualized statistical and probability problems. In addition, a survey questionnaire was administered to gather the students' perceptions, experiences, engagement, and understanding regarding the use of the instructional materials.

Results showed that the materials effectively supported learners' shift from surface-level understanding to deeper cognitive processing, enabling them to better analyze, connect, and generalize statistical and probabilistic concepts. Students demonstrated strong engagement and understanding, supported by real-life contexts that increased motivation and structured scaffolding that built confidence in solving complex mathematical tasks.

The SOLO–HOTS based materials significantly enhanced students' critical thinking skills. Learners moved beyond memorization and developed the ability to justify solutions, interpret data, and analyze probability situations more logically, making lesson a meaningful tool for reasoning rather than an abstract difficulty. Although students experienced productive struggles, particularly in explaining reasoning in writing and solving complex word problems, these challenges reflected deeper engagement with analytical thinking.

Overall, the materials proved effective in promoting critical thinking, though further improvements are needed. Enhancements such as additional worked examples, thinking-process prompts, and visual or multimedia aids are recommended to improve instructional clarity and maximize student learning outcomes.

Keywords: *Critical Thinking Skills, SOLO-HOTS, Statistics and Probability, Contextualized Materials*

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1. Introduction

Mathematics education plays a vital role in developing learners' critical thinking, problem-solving, reasoning, and decision-making skills necessary for the 21st century. Globally, there has been a shift toward student-centered and inquiry-based learning through the use of interactive simulations, contextualized materials, and digital tools to make abstract mathematical concepts more meaningful and engaging. These approaches help learners deepen conceptual understanding and develop higher-order thinking skills rather than relying solely on memorization and routine procedures.

Despite these advancements, many students continue to struggle with Mathematics, particularly in Statistics and Probability, due to traditional lecture-based instruction and limited opportunities for meaningful exploration. International and national assessments, such as the Programme for International Student Assessment (PISA) and the National Achievement Test (NAT), reveal that Filipino learners perform below expected proficiency levels, especially in mathematical reasoning, data interpretation, and problem-solving. These findings highlight the urgent need for innovative instructional strategies that promote critical thinking and mathematical literacy.

In the Philippine context, although the K–12 curriculum under Republic Act No. 10533 emphasizes inquiry-based learning, ICT integration, and conceptual understanding, many schools still face challenges such as limited resources, large class sizes, and insufficient instructional materials. As a Grade 10 Mathematics teacher, it has been observed that many learners struggle with abstract concepts in Statistics and Probability, including randomness, probability, and data interpretation, often resulting in misconceptions and low engagement. Furthermore, this concern is aligned with the provisions of Department of Education Order No. 24, s. 2020, which highlights the importance of improving teaching and learning processes through innovative, learner-centered, and contextualized instructional approaches that enhance students' critical thinking, engagement, and academic performance.

This study focuses on developing and implementing SOLO–HOTS based contextualized instructional materials integrated with the concept of applying real-life situations to lessons in order to enhance students' critical thinking, conceptual understanding, and problem-solving skills in Statistics and Probability. Anchored on the SOLO Taxonomy by Biggs and Collis, the materials guide learners from basic to deeper analytical thinking through contextualized and inquiry-based activities. Supported by the findings of Fernandez and Guzon (2025), the study also highlights the effectiveness of SOLO in assessing deeper conceptual understanding and aligns with the Department of Education's goal of promoting 21st-century skills, digital learning, and improved mathematics education outcomes.

Specifically, it sought answers to the following research questions:

1. What is the level of students' critical thinking as reflected in their responses, classified according to the SOLO taxonomy in terms of:

1.1. pre-structural;
1.2. uni structural;
1.3. multi structural;
1.4. relational; and
1.5. extended abstract?

2. What is the level of manifestation of students' engagement and understanding of the lessons during the implementation of SOLO-HOTS based contextualized materials in Statistics and Probability?

3. To what extent do SOLO–HOTS-based contextualized materials improve the critical thinking skills of Grade 10 students in Statistics and Probability?

4. What difficulties are met by students in utilizing SOLO–HOTS based contextualized activities?

5. Based on the findings of the study, what enhancements activities may be proposed?

Objectives:

1. Determine the level of students' critical thinking as reflected in their responses and classified according to the SOLO Taxonomy in terms of:
   1.1. Pre-structural;
   1.2. Uni-structural;
   1.3. Multi-structural;
   1.4. Relational; and
   1.5. Extended Abstract.

2. Assess the level of manifestation of students' engagement and understanding during the implementation of SOLO–HOTS based contextualized materials in Statistics and Probability.

3. Determine the extent to which SOLO–HOTS based contextualized materials improve the critical thinking skills of Grade 10 students in Statistics and Probability.

4. Identify the difficulties encountered by students in utilizing SOLO–HOTS based contextualized activities.

5. Propose enhancement activities based on the findings of the study to further improve students' critical thinking, engagement, and understanding in Statistics and Probability.

2. Materials and Methods

- **Research Design:**

This study utilized a quantitative approach to determine the effectiveness of SOLO–HOTS based contextualized mathematics materials in enhancing students' critical

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thinking skills. A performance task design was employed using teacher-made assessment analyzed through the SOLO Taxonomy to measure students' level of understanding before and after the intervention. Additionally, survey questionnaires were administered to assess students' engagement, understanding, and difficulties encountered during the implementation of the activities. The gathered data supported and explained the results of the students' performance outcomes.

- **Participants:**

The participants of the study consisted of 45 Grade 10 students from Paharang Integrated School, including 22 male and 23 female learners, selected through purposive total enumeration. They were chosen because they were currently enrolled in Statistics and Probability, where the intervention was implemented. Their varied abilities and performance levels provided an appropriate basis for examining the effectiveness of SOLO–HOTS based contextualized materials in developing critical thinking skills in mathematics.

- **Instruments:**

This study utilized several research tools to gather data on students' critical thinking skills, engagement, and learning experiences using SOLO–HOTS based contextualized mathematics activities. A teacher-made test consisting of open-ended and problem-solving questions in Statistics and Probability was administered before and after the intervention to measure students' critical thinking development. Students' responses were evaluated using an analytical rubric based on the SOLO Taxonomy, classifying answers into pre-structural, uni-structural, multi-structural, relational, and extended abstract levels. The rubric also assessed conceptual understanding, reasoning, accuracy, and application of mathematical processes. In addition, a structured Likert-scale questionnaire was used to determine students' engagement and the difficulties they encountered during the implementation of the activities.

- **Procedure:**

The researcher followed a systematic procedure in gathering the data for the study. Permission to conduct the research was secured from the Principal of Paharang Integrated School, followed by coordination with the class adviser and orientation of the Grade 10 students regarding the study. Consent and assent forms were distributed to ensure voluntary participation. During the implementation, lessons and activities were designed using the SOLO–HOTS taxonomy to enhance students' critical thinking skills. One of the final performance tasks was collected and analyzed using the SOLO levels: pre-structural, uni-structural, multi-structural, relational, and extended abstract. In addition, a survey questionnaire was administered to assess students' engagement and understanding of the lessons, as well as the difficulties they encountered during the implementation of the activities. All gathered data were organized and prepared for statistical analysis, while

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confidentiality and privacy of participants were ensured in accordance with the Data Privacy Act of 2012.

- **Data Analysis:**

The study utilized several statistical tools to analyze the gathered data. Composite mean and weighted mean were used to determine and interpret students' overall responses regarding their engagement, perceived improvement in critical thinking, and difficulties encountered in using the SOLO–HOTS based contextualized mathematics activities. Frequency and percentage were applied to classify and compare students' levels of critical thinking skills before and after the intervention, based on their performance in tests and performance tasks. Ranking was also used to identify the most common difficulties experienced by students during the implementation of the activities. These statistical tools helped evaluate the effectiveness of the SOLO–HOTS materials in improving students' understanding, problem-solving, and critical thinking skills in Statistics and Probability.

3. Results

1. Level of Critical Thinking of the students as classified in SOLO taxonomy

Table 1
Level Of Critical Thinking Of The Students Using SOLO-HOTS Based Contextualized Materials in Statistics and Probability

Items	Frequency	Percentage	Verbal Interpretation	Rank
Pre-Structual	2	4.44	Did not meet expectation	5
Uni-Structual	4	8.89	Fairly Satisfactory	4
Multi-Structual	7	15.56	Satisfactory	3
Relational	14	31.11	Very Satisfactory	2
Extended Abstract	18	40.00	Outstanding	1
Total	**45**	**100.00**		

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Table 1 presents the critical thinking levels of the 45 student-participants based on the SOLO Taxonomy. The results showed that most students demonstrated higher-order thinking skills, with 40% (18 students) reaching the Extended Abstract level and 31.11% (14 students) reaching the Relational level. This means that more than 71% of the students were able to connect ideas, analyze concepts deeply, and apply their understanding to new situations. Only a small number of students remained at the lower levels, with 4.44% at the Pre-structural level and 8.89% at the Uni-structural level.

2. Level of Manifestation of the Students during the Implementation of SOLO–HOTS-based Contextualized Materials in Statistics and Probability

Table 2
Level of Manifestation in Terms of Students' Engagement Using SOLO-HOTS Based Contextualized Materials in Statistics and Probability

Items	Weighted Mean	Verbal Interpretation	Rank
1. The contextualized materials made the lessons more interesting.	3.47	Often Manifested	1
2. I actively participated during Statistics and Probability activities.	3.20	Often Manifested	3
3. The real-life examples made me more motivated to learn.	3.29	Often Manifested	2
4 I enjoyed solving higher-order thinking questions.	3.16	Often Manifested	5
5. I was more focused during lessons using SOLO–HOTS materials.	3.18	Often Manifested	4
Composite Mean	**3.26**	**Often Manifested**	

**Seldom Manifested 1.00-1.49, Manifested 1.50-2.49, Often Manifested 2.50-3.49, Always Manifested 3.50-4.00*

Table 2 shows that students' engagement during the implementation of the SOLO–HOTS based contextualized materials was "Often Manifested," with a composite mean of 3.26. The highest-rated indicator was that the contextualized materials made the lessons more interesting, with a weighted mean of 3.47. Students were also motivated by real-life examples and actively participated in the activities, although the HOTS tasks required a high level of cognitive effort.

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Table 3
Level of Manifestation in Terms of Understanding the Lesson Using SOLO-HOTS Based Contextualized Materials in Statistics and Probability

Items	Weighted Mean	Verbal Interpretation	Rank
1. The materials helped me understand the lesson clearly.	3.40	Often Manifested	2
2. I can connect the lesson to real-life situations.	3.27	Often Manifested	3
3. The step-by-step activities helped me build my understanding gradually.	3.44	Often Manifested	1
4. I feel more confident answering HOTS questions.	3.22	Often Manifested	4.5
5. I understand Statistics and Probability better because of these materials.	3.22	Often Manifested	4.5
Composite Mean	**3.31**	**Often Manifested**	

**Seldom Manifested 1.00-1.49, Manifested 1.50-2.49, Often Manifested 2.50-3.49, Always Manifested 3.50-4.00*

Table 3 shows that the use of SOLO–HOTS based contextualized materials helped improve students' understanding of Statistics and Probability, with a composite mean of 3.31 interpreted as "Often Manifested." The highest-rated indicator was the use of step-by-step activities (3.44), which helped students better understand the lessons through guided and organized learning. Students also reported that the materials made the lessons clearer and helped them connect mathematical concepts to real-life situations.

3. Extent of Improvement in Critical Thinking Skills Using SOLO–HOTS-Based Contextualized Materials in Statistics and Probability

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Table 4
Improvement of Critical Thinking Skills in Statistics Using SOLO-HOTS Based Contextualized Materials

Items	Weighted Mean	Verbal Interpretation	Rank
1.The contextualized materials helped me analyze statistical data more deeply.	3.38	Average Extent	1
2. I can interpret graphs, tables, and charts more confidently after using the materials.	3.27	Average Extent	4.5
3.The activities helped me explain statistical results using my own reasoning.	3.31	Average Extent	2
4.The lessons encouraged me to think beyond memorizing formulas.	3.29	Average Extent	3
5. I can now justify my answers in Statistics using logical explanations.	3.27	Average Extent	4.5
Composite Mean	**3.30**	**Average Extent**	

**Not Extent 1.00-1.49, Least Extent 1.50-2.49, Average Extent 2.50-3.49, Great Extent 3.50-4.00*

Table 4 shows that the SOLO–HOTS based materials helped improve students' critical thinking skills in Statistics and Probability, with a composite mean of 3.30 interpreted as "Average Extent." The highest-rated indicators were students' ability to analyze statistical data more deeply (3.38) and explain answers using logic and mathematical knowledge (3.35).

Table 5
Improvement of Critical Thinking Skills in Probability Using SOLO-HOTS Based Contextualized Materials

Items	Weighted Mean	Verbal Interpretation	Rank
1.The contextualized activities helped me understand probability concepts better.	3.38	Average Extent	1
2. I can analyze probability problems more critically.	3.27	Average Extent	4
3. The materials helped me apply probability in real-life situations.	3.31	Average Extent	3
4.I can explain why an event is likely or unlikely to happen.	3.24	Average Extent	5
5.The lessons improved my ability to solve complex probability problems.	3.36	Average Extent	2
Composite Mean	**3.31**	**Average Extent**	

**Not Extent 1.00-1.49, Least Extent 1.50-2.49, Average Extent 2.50-3.49, Great Extent 3.50-4.00*

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Table 5 shows that the SOLO–HOTS approach positively improved students' understanding of Probability, with a composite mean of 3.31 interpreted as "Average Extent." Students were better able to understand complex probability concepts (3.38), solve difficult probability problems (3.36), and recognize the importance of probability in real-life situations (3.31). However, some students still had difficulty explaining the logic behind probability concepts (3.24).

4. Difficulties met by the learners in utilizing SOLO–HOTS based contextualized activities.

Table 6
Difficulties Encountered of the Students During the Utilization of SOLO-HOTS Based Contextualized Materials

Items	Weighted Mean	Verbal Interpretation	Rank
1. Some activities were too challenging for me.	2.76	Agree	1
2. I had difficulty analyzing complex word problems.	2.56	Agree	4.5
3. I struggled in explaining my reasoning in writing.	2.60	Agree	3
4. I needed more time to complete the HOTS-based tasks.	2.62	Agree	2
5. I felt confused with some contextualized examples.	2.56	Agree	4.5
Composite Mean	**2.62**	**Agree**	

**Strongly Disagree1.00-1.49, Disagree 1.50-2.49, Agree 2.50-3.49, Strongly Agree 3.50-4.00*

Table 6 presents the difficulties encountered by students while using the SOLO–HOTS based activities. The highest challenge experienced by students was the complexity of the tasks, with a weighted mean of 2.76 interpreted as "Agree." Students also found that the activities required more time and mental effort (2.62), had difficulty expressing their ideas in writing (2.60), and struggled with complex word problems and contextualized examples (2.56).

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5. Proposed Enhancement Activities

Based on the findings of the study, enhancement activities were proposed to further improve the critical thinking skills of Grade 10 students in Statistics and Probability using SOLO–HOTS based contextualized materials. The results showed that students became more engaged and understood the lessons better when activities were connected to real-life situations and involved higher-order thinking skills. However, some students still experienced difficulties in analyzing, interpreting, and applying statistical concepts.

To address these challenges, the proposed enhancement activities include contextualized problem-solving tasks, collaborative activities, data interpretation exercises, and reflective tasks. These activities aim to strengthen students' critical thinking, understanding, and problem-solving skills in Mathematics.

4. Discussion

The study showed that the use of SOLO–HOTS based contextualized materials helped improve the critical thinking skills of Grade 10 students in Statistics and Probability. Most students reached the higher levels of the SOLO Taxonomy, particularly the Relational and Extended Abstract levels, which means that they were able to connect ideas, analyze concepts deeply, and apply their learning to new situations. Only a few students remained at the lower thinking levels, showing that the activities were effective in developing higher-order thinking skills.

The findings also revealed that students were actively engaged during the implementation of the activities. The contextualized and real-life examples made the lessons more interesting and meaningful, which increased students' motivation and participation. Students showed better understanding of the lessons because the activities were presented in a step-by-step and organized manner, helping them connect mathematical concepts to real-life situations.

Moreover, the SOLO–HOTS based materials improved students' ability to analyze data, explain answers logically, and solve complex problems in Statistics and Probability. Students learned to move beyond simple computation and memorization toward deeper reasoning and critical thinking. The use of contextualized activities also helped them appreciate the importance and practical application of probability and statistics in daily life.

Despite these positive results, students still encountered some difficulties during the implementation of the activities. Many students found the tasks challenging and time-consuming because they required deeper analysis and reasoning. Some learners also had difficulty expressing their ideas in writing and solving complex word problems. However, these challenges were considered productive struggles that contributed to the development of their critical thinking skills.

Based on the findings, enhancement activities were proposed to further strengthen students' critical thinking and understanding in Statistics and Probability. These include contextualized problem-solving activities, collaborative learning tasks, data interpretation exercises, and

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reflective activities that encourage deeper analysis and real-life application of mathematical concepts.

5. Conclusion

The study concludes that the SOLO–HOTS based materials effectively helped students shift from surface-level learning to deeper cognitive processing, as most learners reached the Relational and Extended Abstract levels, showing their ability to understand, connect, and generalize concepts. Students also demonstrated consistent engagement and understanding, supported by real-life examples and step-by-step scaffolding that improved motivation and confidence in learning complex mathematical ideas. The materials significantly enhanced students' critical thinking skills by moving them beyond memorization toward analyzing, justifying, and applying statistical and probabilistic concepts, making Probability more meaningful as a tool for logical reasoning. Although students experienced productive struggles due to the challenging and time-consuming nature of the tasks, these difficulties reflected deeper learning, particularly in written reasoning and complex problem-solving. Overall, while the intervention was effective, further improvements such as more worked examples, thinking-process prompts, and visual or multimedia aids are needed to enhance instructional clarity and student learning outcomes.

Based on the findings, the study recommends:

1. Teachers may incorporate "easy-to-difficult" learning steps and "thinking process" notes in lesson journals to guide learners toward advanced SOLO levels.
2. Teachers may use examples that are connected to the learners' daily experiences to make Statistics and Probability lessons more interesting and meaningful.
3. Written learning materials may be enhanced with infographics, flowcharts, and QR code videos to give learners different ways of understanding problem-solving concepts. Higher-order thinking activities may also be introduced with worked examples that clearly show the step-by-step thought process needed in solving the tasks.
4. More time may be given to activities that involve higher-order thinking skills since students often need enough time to analyze, reflect, and understand situations deeply compared to routine exercises.
5. Teachers may integrate SOLO–HOTS based contextualized materials in worksheets, lesson plans, and performance tasks by using real-life and localized situations that encourage students to analyze, explain, and apply concepts in meaningful ways.
6. Similar studies with in-depth and wider scope may be conducted to validate and confirm the effectiveness of SOLO- HOTS based contextualized materials in improving students' critical thinking skills.

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