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Students' Level of Understanding in Mathematics based on Structure of Observed Learning Outcomes Taxonomy

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***Abstract*—** The state of mathematics education in the Philippines continues to be a pressing issue, highlighted by the ongoing low performance of Filipino students in global tests like the Programme for International Student Assessment (PISA). These results prompt crucial inquiries regarding the extent of students' comprehension and the effectiveness of existing teaching methods. In response to this issue, the current study examines Grade 10 students' understanding of mathematics through the lens of the Structure of Observed Learning Outcomes (SOLO) Taxonomy as a framework for evaluation. Employing a descriptive qualitative research design, the study utilized PISA-based math word problems and a SOLO-aligned rubric to assess the level of understanding demonstrated by students. Students encountered significant difficulties with tasks requiring relational and extended abstract thinking and often lacked the ability to express detailed mathematical reasoning. Analysis of assessment revealed four key learning patterns: (1) emphasis on basic recall and single-step procedures, reflecting unistructural understanding; (2) execution of multiple steps with limited conceptual connection, characteristic of multistructural thinking; (3) initial efforts to connect ideas, though often incomplete or inconsistent, indicating emerging relational reasoning; and (4) absence of abstraction and generalization, as no students reached the extended abstract level.The study recommends integrating the SOLO Taxonomy into classroom assessment, promoting PISA-style problem-solving, and using SOLO-based practice test to enhance mathematical reasoning. Aligning teaching methods with cognitive development theories can greatly enhance students' mathematical skills and overall learning results.

***Keywords*—** cognitive development, level of understanding, SOLO taxonomy.

I. INTRODUCTION

Mathematics plays a big part in human lives that delves into abstract concepts and has broad applications in science, technology, economics, and daily life. Philippine Department of Education K-12 curriculum aimed to enhance students' critical thinking and problem solving skills. However, challenges persist. Bascones et al., (2024) was suggested that students must be supported in their learning by providing doable tasks and exciting problems in mathematics to boost their attitude and self-efficacy. Gamit (2022) revealed a weak mathematical education foundation among students, which requires immediate attention. Bernardo et al. (2022) noted that the education sector must address the concern about the curriculum and instructional essentials. According to Cardino et al., (2020), mathematics educators can greatly affect students who feel unmotivated in the math subject. Previous studies highlight that poor performance in math is linked to weak foundational knowledge, low self-efficacy, and socio-psychological factors.

According to Apelo and Arcenas (2022), Filipino students' performance in mathematics is declining. In a study of Magas (2023) reported that the Philippines ranked the lowest out of 58 countries in the 2019 Trends in International Mathematics and Science Study (TIMSS). Students' scores reflect serious learning gaps. National assessments, such as the National Achievement Test (NAT), also show low proficiency in math. Analyzing the situation in the Philippines alongside eleven (11) other nations, it offered a comprehensive examination of the PISA 2018 mathematics results for twelve (12) countries in the Asia-Pacific area (Bayirli, et. al 2023). The Philippines was ranked among the lowest in reading comprehension in the study conducted by the Organization for Economic Cooperation and Development (OECD) (Paris, 2019). The 2022 Programme for International Student Assessment (PISA) revealed that Filipino students scored significantly lower than the average of other OECD countries. According to Golla & Reyes (2020) the results of PISA revealed that across all three subject areas, including literacy, science, and mathematics,

Filipino students performed poorly. Therefore, teachers and researchers strive to understand the elements that affect mathematical skills among students. To enhance Filipino students' overall numeracy skills and to equip for PISA evaluations, these findings show the need for better teaching resources.

The poor performance results among Filipino learners highlight the need for a reform initiative focused on improving teachers' subject knowledge and pedagogy to enhance student performance. National Educators Academy of the Philippines (NEAP) and Research Center for Teacher Quality (RCTQ) have collaborated to support the said concern. They developed a resource, a professional development for technical support for educators. Versoza & Vistro-Yu (2019), for effective implementation and management of limitations, a curriculum aimed at enhancing the mathematics curriculum must provide ongoing and practical guidance. The content of the HOTS-PLPs on which the DepEd presented to teachers are aligned with the Structure of Observed Learning Outcomes (SOLO) framework, which highlights the increasing complexity and quality of response to tasks and questions relevant to specific activities or domains. These are essential for promoting deep learning and critical thinking. By providing a framework to understand and evaluate the advancement of students' thinking abilities, the SOLO Taxonomy fits perfectly with this goal.

Ilhan & Gezer (2017) highlights that SOLO Taxonomy proved to be more reliable, specifically in determining the cognitive level of assessment questions, and it also suggests that it is more consistent in its application. The utilization of SOLO Taxonomy gained significant insights into learners' difficulties, aiming to improve problem-solving and also their learning experiences (Dacsa, 2022). Salmon, & Barrera (2021) stated that "Questions create zones of proximal development when teachers are able to grasp their students' prior knowledge, thinking, and inquiries to scaffold them to the next level", teachers posed a problems or questions during instruction and its foster a higher-order thinking. Ranging from simple to more complex, a framework for problem posing categorizes questions based on cognitive demand. Based on the study of Mulbar, et al., (2017) and Kaharuddin et al., (2020) they also used SOLO Taxonomy to identify the level of progression of the students. Students' success in Math and critical thinking skills relies on their word problem-solving skills, which many find challenging. Furthermore, employing the SOLO framework and focusing on problem posing, educators can enhance student engagement and problem solving abilities and it will lead to enhancing academic achievement. This study emphasize specific challenges in math learning and aims to help teachers improve their teaching methods for better outcome. The study provides insights for curriculum development and education policy by tracking students' progress with SOLO framework.

Department of Education had initiated the incorporation of the SOLO Taxonomy into the curriculum because of the poor results of Philippines in international assessment like PISA, minimal research investigated its application to real assessment tasks like those found in PISA, and employing SOLO Taxonomy to classroom practices is new for the DepEd educators.

This study specifically focused on Grade 10 students at Lajong National High School during the school year 2024–2025. The focus on this particular grade was intentional, as these students had completed the K–10 Mathematics curriculum and were equipped to address the research questions effectively. The study adopted and employed selected items from the Programme for International Student Assessment (PISA).

The objective of this research study was to assess the students' level of understanding in Mathematics based on SOLO Taxonomy, among the Grade 10 students of Lajong National High School for the academic year 2024-2025. To achieve this aim, the study set the following specific objectives: 1) to determine the level of understanding each student demonstrated based on the SOLO Taxonomy; and 2) to propose a SOLO-based practice test in Mathematics.

II. METHODOLOGY

This study utilized a descriptive qualitative research design to assess the level of understanding of Grade 10 students in mathematics through the Structure of Observed Learning Outcomes (SOLO) framework. The purpose of this research was to provide an in-depth examination of students' mathematical thinking and problem-solving approaches, as reflected in their responses to selected tasks. The study employed purposive sampling. The data were gathered from 28 Grade 10 students who answered mathematics tasks adopted from PISA items. These items were aligned with the SOLO Taxonomy to determine students' levels of understanding.

For the first objective, which focused on determining students' level of mathematical understanding,

responses were classified into five SOLO levels: pre-structural, unistructural, multistructural, relational, and extended abstract.

To analyze the distribution of students across these levels, the researcher used statistical tools such as frequency count and percentage.

The percentage of students at each SOLO level was calculated based on their scores for each PISA item. This study used a rubric based on the Structure of Observed Learning Outcomes (SOLO) Taxonomy.

The rubric sorted students' responses into five levels: Prestructural (0), Unistructural (1), Multistructural (2), Relational (3), and Extended Abstract (4). It evaluated student performance on four math tasks taken from PISA: Triangular Pattern, Car Purchase, DVD Sales, and Spinners.

Each level showed how well students understood the material, ranging from no meaningful response at the Prestructural level to advanced reasoning and predictions at the Extended Abstract level.

The researcher carefully designed and refined the rubric for each task to match the specific thinking skills needed. For example, in the Triangular Pattern task, a student at the Relational level counted, calculated, and interpreted percentages in context.

A student at the Extended Abstract level made justified predictions about future patterns. In the Spinners task, students at the highest level analyzed repeated simulation data to demonstrate understanding of the Law of Large Numbers.

To improve the rubric, they focused on clarity, specificity, and alignment with the SOLO descriptors.

They provided detailed examples for each level to ensure consistent scoring. The rubric was task-specific while aligning with the overall principles of the SOLO framework.

This approach allowed for both scores, along with the SOLO levels and qualitative insights into students' learning.

It helped educators and researchers understand not just if students got the right answer, but also how well they grasped the mathematical concepts involved.

The rubric provided clear assessment criteria, following the SOLO taxonomy's structured scoring system to measure students' understanding effectively. The students' responses were analyzed using the Structure of Observed Learning Outcomes (SOLO) taxonomy rubric to determine their level of mathematics understanding.

For the second objective, which involved proposing a relevant output. Based on the results, the proposed output was designed to address the learning gaps identified in the study.

This proposed output aimed to support students in improving their mathematical reasoning and problem-solving skills by providing strategies tailored to their needs.

III. RESULTS

Students' level of mathematics understanding based on SOLO taxonomy

In this study, students' responses to each item of the test and classifying them to its level, the analytic rubric, which is based on the SOLO framework, must be considered. SOLO-based rubric was used to determine the level of mathematics understanding of the students.

The scoring rubric is based on the SOLO framework, with scores ranging from 0 to 4 corresponding to the levels of prestructural, unistructural, multistructural, relational, and extended abstract.

After scoring the responses or answers of the students in 4-item PISA test, the researcher determined the levels of the students.

It outlines five levels of understanding, ranging from basic recall to complex application and creation of knowledge.

The researcher employed statistical tools such as frequency count and percentage. The percentage of students at each level was derived from their PISA scores.

The table presents a summary of students' levels of understanding based on the SOLO (Structure of Observed Learning Outcomes) Taxonomy for different PISA (Programme for International Student Assessment) items.

The table records the number of students at each level of understanding based on SOLO Taxonomy and accompanied with the corresponding percentages.

Table 1: *Summary Results on the students level of understanding based on SOLO Taxonomy*

Item	Level of understanding based on SOLO Taxonomy	No. of students (Frequency)	Percentage %
1	Prestructural Unistructural Multistructural Relational Extended Abstract	0 2 26 0 0	0 7.14 92.86 0 0
2	Prestructural Unistructural Multistructural Relational Extended Abstract	0 2 21 5 0	0 7.14 75 17.86 0
3	Prestructural Unistructural Multistructural Relational Extended Abstract	2 2 24 0 0	7.14 7.14 85.72 0 0
4	Prestructural Unistructural Multistructural Relational Extended Abstract	0 28 0 0 0	0 100 0 0 0

Proposed Output based on the findings of the study

A SOLO and competency-based math practice test. This math practice test is designed to help students improve their cognitive processing and problem-solving skills by incorporating Superitems, which are structured sets of questions aligned with the Structure of the Observed Learning Outcome (SOLO) Taxonomy. The reference of this proposed output is the revised K-1O curriculum guide. The content of this proposed output are started with an introduction followed by the following: Learning competencies, examples of Superitem (Problem) accompanied by SOLO levels question with an answer, Assessment, and Answer Key.

On the examples of the Superitems with corresponding questions categorized according to different SOLO levels: Unistructural, Multistructural, Relational, and Extended Abstract, and these are together with the answer. And on the practice test and assessments, there are also questions categorized according to 4 different SOLO levels. To support student learning, the final section of the math practice test will feature an answer key, allowing students to check their responses and monitor their progress. This SOLO and competency-based math practice test is proposed based on research findings of this study that indicate most students currently fall within the Unistructural and Multistructural levels. These levels suggest that while students can recall isolated pieces of information, they struggle with integrating and applying their knowledge in more complex ways.

Additionally, students are not familiar with the SOLO framework, which limits their ability to consciously progress to higher levels of understanding. By providing structured exercises that gradually guide students through the different SOLO levels, the mathematics competency-based practice test aims to enhance learning, develop critical thinking skills, and promote deeper comprehension of mathematical concepts. The content of math practice test aligned with the learning competencies from the Revised K-10 Mathematics curriculum guide from the Department of Education (DepEd), covering key content areas such as Number and Algebra (NA) , Measurement and Geometry (MG), and Data and Probability (DP). Each section included progressively structured Superitems that challenge students to move beyond basic recall and develop a more comprehensive understanding of these mathematical concepts. By ensuring alignment with the combination of different learning competencies from the curriculum guide, the practice test will not only address learning gaps but also support the achievement of some of the learning competencies set by DepEd. The math practice test introduces the SOLO framework for students and teachers. It explains each level clearly, helping students see where they stand and set goals to improve. This

resource is useful for both independent study and classroom learning.

IV. DISCUSSION

Students' level of mathematics understanding based on SOLO Taxonomy

The findings of this study present valuable insights into the level of mathematics understanding of Grade 10 students based on the Structure of Observed Learning Outcomes (SOLO) Taxonomy. Students' answers across four test items revealed varying levels of comprehension, with most students performing at the multistructural and unistructural levels. These results have important implications for teaching strategies and curriculum improvement in mathematics education.

Across all four test items, the majority of students demonstrated a multistructural level of understanding, meaning they could recall and apply multiple aspects of a concept but struggled to integrate them into a coherent whole. This was most evident in Item 1, where 92.86% of students fell within this category. Similarly, in Items 2 and 3, 75% and 85.72% of students, respectively, reached the multistructural level. However, no students were able to reach the extended abstract level in any of the test items, indicating a lack of ability to generalize and apply their knowledge to unfamiliar contexts. A concerning result was found in Item 4, where all students (100%) remained at the unistructural level. This suggests that while students were able to follow instructions and utilize a given tool, they failed to demonstrate any deeper understanding or make meaningful connections. The absence of relational and extended abstract level responses across all items underscores the need for improved instructional methods that emphasize critical thinking and conceptual integration.

Analyzing the specific test items, Item 1 showed that 92.86% of students reached the multistructural level, indicating that they understood various aspects of the problem but struggled to connect their ideas cohesively. Only two students were at the unistructural level, with no representation at the relational or extended abstract levels.

In Item 2, the majority (75%) of students performed at the multistructural level, while 17.86% demonstrated relational understanding, meaning they were able to integrate and justify their responses effectively. The presence of some students at the relational level is an encouraging sign but highlights the need for instructional strategies that push more students toward deeper comprehension.

Item 3 presented a similar trend, with 85.72% of students achieving the multistructural level, while two students each fell into the prestructural and unistructural levels, revealing gaps in foundational understanding. The absence of relational and extended abstract responses suggests that students are not yet comfortable with higher-order thinking and justifications.

Item 4 presented a significant challenge, as all 28 students (100%) were classified at the unistructural level. This result suggests a significant gap in students' ability to apply and analyze mathematical concepts beyond basic procedural execution, emphasizing the need for targeted interventions in this area.

The results reveal that most of the students are at multistructural level in adopted PISA items similar to the result and according to the study of Karahan & Ergene (2023), it is said that "In the majority of the studies, it was found that the multi-structural level was more dominant than the other SOLO taxonomy levels." It indicate that while students can engage with multiple aspects of a problem, they struggle to connect and apply their knowledge meaningfully.

The absence of relational and extended abstract responses suggests a need for instructional strategies that promote deeper comprehension. Teachers should encourage students to explain their reasoning, justify their answers, and apply concepts to new situations. Inquiry-based learning should be incorporated to engage students in problem-solving tasks that require analysis, evaluation, and creativity.

These findings suggest that current teaching methods may not support higher-order thinking, problem-solving, or reflection skills effectively. There is an urgent need for changes in teaching strategies that include inquiry-based learning, teamwork on problems, and reflective activities. These approaches may help students advance from basic understanding to deeper comprehension. Teachers also need to address language barriers, as these hinder students' abilities to grasp and solve word problems, which is a critical skill in global tests like PISA. Recent research backs up these findings. The OECD (2023) highlights that math literacy means being able to use math in real-life situations, which calls for reasoning, analysis, and critical thinking skills linked to higher levels of understanding can be used as a systematic way that describes how learners'

understanding builds from easy to difficult (Damopolii et al., 2020).

These results indicate the need for teaching methods that go beyond simply teaching procedures and focus on deeper learning. Current teaching approaches may not be effectively helping students reason, justify, and extend their understanding. Teaching needs to emphasize conceptual understanding, problem-solving, and reasoning. Students should learn to connect different ideas and explain their thought processes. Additionally, assessments should include formative practices that help identify where students are in their thinking and guide them to higher levels of understanding.

Additionally, Boaler (2016) argues for a focus on problem-solving in learning math instead of just memorizing procedures. Kapur (2018) emphasizes that "productive failure" can lead to deeper understanding, where students tackle tough problems that might initially be frustrating but help them learn through reflection and teacher support.

The study highlights significant findings for teaching and assessing mathematics for Grade 10 students. Most students' level of understanding in Mathematics was at the multistructural level, meaning they could recognize and use individual pieces of information but struggled to connect them in a meaningful way. These are identified as moderate learning outcomes (Kaharuddin & Hajeniati, 2020). A few students grasped the relational level, but none presented extended abstract thinking, which involves generalizing ideas and applying them creatively to new situations. This indicates that while students can follow procedures and solve routine problems, they often find it hard to synthesize information, reason through complex situations, and apply concepts in real life—skills needed in today's learning and global assessments like PISA.

Mathematics SOLO-based Practice Test

The study shows a clear need to change how we teach mathematical problem-solving in Grade 10. Most students are at the Unistructural and Multistructural levels of the SOLO Taxonomy. Similar to the study of Agustinsa, et. al (2021), the level of understanding of students is mostly at are multistructural level. Additionally, Garcia & Despojo (2024) state in their research findings that relational thinking skills were found to be the least developed competency. This means they can remember and use isolated facts or procedures, but they find it hard to connect these ideas into a meaningful whole or apply them to new situations. These skills are needed at the Relational and Extended Abstract levels. The lack of higher-level thinking in students' responses highlights the difficulty they have when asked to reason, generalize, or connect concepts.

To address these concerns, educators should develop a mathematics SOLO-based practice test. This practice test would use "Superitems," which are a series of questions designed to gradually increase in complexity according to the SOLO levels. This approach is supported by research of Muchiri & Zaberio Mawira (2020), "a well-set and planned math practice paper combined with other instructional resources and practices can be used as a differentiated teaching strategy towards achieving math proficiency". By integrating the SOLO framework into teaching and assessment, students will not only learn mathematical content but also understand how their thinking changes. This awareness is important for helping them set goals and take charge of their own progress.

Recent literature backs this approach. Koh et al. (2018) highlight how formative assessment tools, like SOLO, can help students learn to manage their own learning and think critically. Their research shows that when students know the criteria for deeper thinking, they are more likely to engage in meaningful learning tasks. Similarly, Lim and Chapman (2015) found that using the SOLO Taxonomy in secondary math improved students' abilities to reason, reflect, and apply concepts in different situations. Moreover, the OECD (2023) PISA framework points out that success in math today requires more than just following steps; it needs critical thinking, logical reasoning, and solving complex problems. These skills are essential for reaching the relational and extended abstract levels of SOLO.

The implementation of Mathematics (Structure of Observed Learning Outcomes) SOLO-based math practice test can serve as a structured resource to guide students through progressively complex levels of understanding. Also, formative assessments should be designed to diagnose students' SOLO levels and provide targeted interventions. The proposed development of a practice test aims to enhance students' cognitive processing and problem-solving abilities by integrating structured sets of questions aligned with the SOLO Taxonomy. This approach is grounded in research indicating that many students predominantly operate at the Unistructural and Multistructural levels, where they

can recall isolated pieces of information but struggle with integrating and applying knowledge in more complex contexts. And also by understanding the learning styles of students, teachers will be guided in designing different strategies to help students enhance learning for their improved performance in mathematics (Cardino et al., 2020).

Developed by John B. Biggs and Kevin F. Collis, the SOLO Taxonomy explains levels of increasing complexity in students' understanding. The five levels include Pre-structural, where the student lacks understanding and provides irrelevant responses; Unistructural, where the student focuses on a single relevant aspect; Multistructural, where multiple relevant aspects are considered independently without integration; Relational, where different aspects are connected into a coherent whole; and Extended Abstract, where the student generalizes concepts and applies them to novel situations (Biggs & Collis, 1982). This model provides a structured framework for assessing the depth of student learning, transitioning from surface-level knowledge to deep understanding.

Superitems, a STEM or real-life problems used as an assessment tool in practice tests, are structured question sets designed around a common problem, with progressive levels of complexity. According to the study by Garil & Dio (2024) on a systematic review of problem-based learning (PBL) and its effects on students' problem-solving and critical-thinking skills, it was found that 100% of the studies reviewed indicated that PBL has a significant positive impact on these skills. Therefore, PBL should be incorporated into teaching and learning practices.

Each Superitem begins with a stimulus, followed by related questions that require students to demonstrate different levels of understanding based on the SOLO Taxonomy. This format allows educators to evaluate students' cognitive processes and identify areas for improvement. For instance, in a trigonometry, students may be presented with a real-world problem involving angles and distances. Initial questions may test recall of trigonometric ratios (Unistructural), while subsequent questions may require solving multi-step problems (Relational) and formulating generalizations or new problems (Extended Abstract).

The proposed practice test aligns with the new revised K-10 Mathematics curriculum guide (MATATAG) from the Department of Education (DepEd), covering key content areas such as Number and Algebra (NA), Measurement and Geometry (MG), and Data and Probability (DP). Each section of lessons includes progressively structured Superitems that challenge students to move beyond basic recall and develop a more comprehensive understanding of these mathematical concepts. By ensuring alignment with the curriculum guide, the practice test addresses learning gaps and supports the achievement of different learning competencies set by DepEd.

The math practice test introduces the SOLO framework to both students and teachers, providing clear explanations of each level to help students self-assess and set goals for improvement. This resource is designed for both independent study and classroom use, offering a structured approach to learning that supports student growth and enhances mathematical skills. Studies have shown that using the SOLO Taxonomy in teaching mathematics significantly improves students' conceptual understanding, as it offers a clear pathway for learning progression.

A practice test that aligns to the SOLO taxonomy helps students improve their critical thinking and understand math concepts better. Research shows that activities can help students advance from basic understanding to more complex thinking. When students engage with math in an organized way, they move past memorization and learn to analyze and apply concepts in real life. This step-by-step approach not only boosts academic performance but also builds important problem-solving skills. The practice test is designed for problem-based learning and can be used both individually and collaboratively in groups. Students are encouraged to work together to tackle complex, real-world problems with guidance from their math teacher. Evidence supports the effectiveness of this method in promoting a deep understanding of content (Allen, et. al 2011).

Using SOLO principles in math assessments improves students' math abilities and prepares them for real-world challenges. Utilizing Problem-based Learning encouraged students to think critically by planning, discussing, formulating questions, analyzing issues, and proposing solutions to environmental challenges (Asyari et al., 2016).

As students develop their problem-solving skills, they become better at handling difficulties and adapting to new situations. This educational method promotes

meaningful learning and ensures students are ready for their future.

V. CONCLUSION AND RECOMMENDATION

Conclusions

This study reveals that many Grade 10 students struggle to progress to a higher levels of understanding in Mathematics, as categorized by the SOLO Taxonomy.

Most students are classified at the Unistructural and Multistructural levels, indicating their ability to recall facts and perform simple calculations and its suggests a surface level grasp of mathematical ideas, yet they find it challenging to connect concepts or apply their knowledge in more complex situations.

There's no students reached the Extended Abstract Level, and its suggests a lack of higher-order thinking and problem solving skills.

The students' responses in problem solving test shows a significant challenges in answering questions requiring relational and extended abstract levels.

The mentioned higher levels, which involve making connections between concepts and applying them in different contexts or new ideas, were difficult for the students.

Students progression to higher SOLO levels especially relational and extended abstract was significantly inhibited.

The development of the Mathematics SOLO-based Practice Test is also encouraged, as it serves as a vital resource for guiding the students in evaluating and enhancing their responses in solving word problem tasks.

Engaging with the SOLO-based practice test, learners can better articulate their thought processes and demonstrate reasoning across different levels of complexity.

Furthermore, the researcher of this study emphasizes the importance of focusing on strategies for problem-solving and reasoning skills.

Math teachers must encourage the students to explore a range of solving strategies to arrive at accurate answers regardless of methods used in a problem.

Recommendations

Based from the conclusions of the study, these are the following recommendations.

First, schools and other institutions must incorporate practice tests specifically reflect the four levels of the SOLO Taxonomy for enhancing students familiarity with the types of questions in assessment that may encounter and helping them to develop their skills for a complex real life problem-solving.

Teachers must encourage students to always explain their reasoning in detail. In this part they may proceed to the relational level of SOLO Taxonomy in which they may connect or explain the relationships of the context.

This helps students not only understand mathematical concepts but also communicate them effectively.

Employing open-ended questions in mathematics real life word problem solving tasks for extended abstract level of SOLO Taxonomy allows students to connect different ideas and apply their knowledge meaningfully.

It is very important in preparing students for higher level mathematics and academic challenges the fostering of critical thinking and also the clear reasoning.

Additionally, it is recommended that the Department of Education (DepEd) validate and reproduce learning materials such as learning activity sheets, practice tests, or modules with simple to complex tasks or aligned with the SOLO Taxonomy.

Taxonomy alignment across instructional materials will promote consistency in teaching and learning strategies, in assessment style, and also for raising quality of mathematics education nationwide.

These learning resources should be standardized and made accessible to all educators across the Philippines to ensure uniform exposure to cognitive development levels and a clearer understanding of the students' current learning progressions.

Schools can foster a more comprehensive and equitable learning environment that not only prepares students for solving complex problems but also a deeper and more meaningful understanding of mathematical concepts, by employing these recommendations of the study.

APPENDIX PISA ITEMS

MATHEMATICS

ITEM #1

CAR PURCHASE
Question

Refer to "Car Purchase" on the right. Use the Cost Estimator to help you answer the question below.

Tania is planning to purchase a new car. She wants to know how much it will cost to purchase a car and drive it for the first year.
She finds this Cost Estimator online and makes the following estimates:

- She will drive an estimated distance of 20 000 km this year.
- The average cost of fuel will be 1.54 zeds per litre.
- The estimated maintenance costs are 250 zeds in the first year.

Based on Tania's estimates, which car would cost her the **least** to purchase and drive in the first year?

A. Car A
B. Car B
C. Car C
D. Car D

CAR PURCHASE

The prices and fuel consumption of four cars that Tania is considering purchasing are shown in the table below.

Fuel consumption is the number of litres of fuel needed to drive 100 kilometres. It is an estimate based on a combination of city and highway driving.

	Car A	Car B	Car C	Car D
Car Price (zeds) Car price includes all taxes and registration fees.	8000	8700	9900	10 500
Fuel Consumption (L/100 km)	18.9	15.7	12.4	14.1

Some of the cells in the Cost Estimator have been filled in based on Tania's estimates.

COST ESTIMATOR

Car Price (zeds)	
Fuel Consumption (L/100 km)	
Estimated Distance Driven (km)	20 000
Average Cost of Fuel (zeds/L)	1.54
Estimated Maintenance Costs (zeds)	250

Clear | Calculate

RESULTS

ANSWER

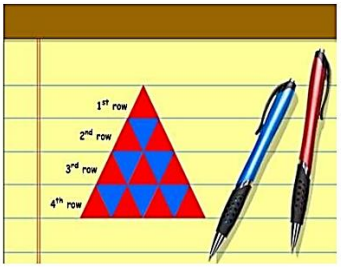
Triangular Pattern
Question
Refer to "Triangular Pattern" on the right. Click on a choice to answer the question.
What percentage of the triangles in the first four rows of Alex's pattern are blue?

A. 37.5%
B. 50.0%
C. 60.0%
D. 62.5%

TRIANGULAR PATTERN

Alex drew the following pattern of red and blue triangles.

The first four rows of the pattern are shown below.



Answer

DVD Sales
Question 1 / 2
Refer to "DVD Sales" on the right. Click on the choices in the table to answer the question.
Are the statements in the table below supported by the information shown in the graph? Click on either **Yes** or **No** for each statement.

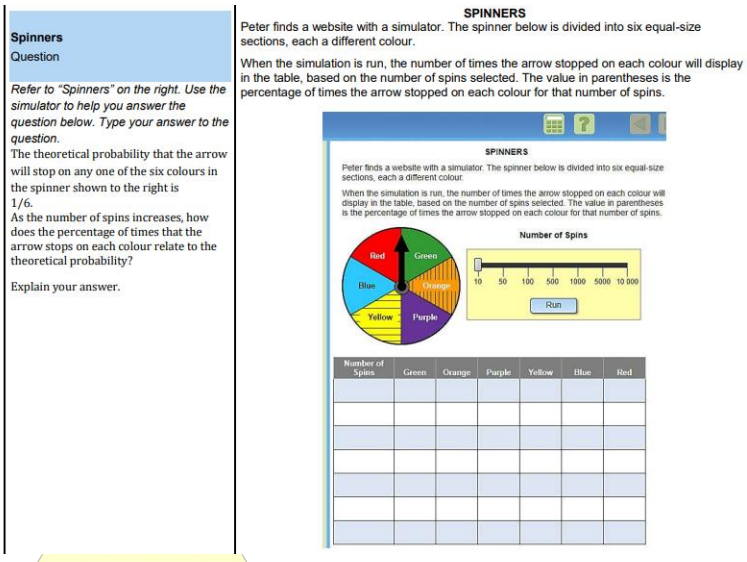
Statement	Yes	No
The number of DVDs sold declined by about 50% from 2008 through 2014.	○	○
The number of DVDs sold declined by the same amount each year from 2008 through 2014.	○	○
The slope of the line is the average yearly decline in DVDs sold from 2008 to 2014.	○	○

DVD SALES

The total number of DVDs sold each year in the United Kingdom from 2008 to 2014 is shown in the graph below.

The values on the horizontal axis represent the number of years **after** 2008. Place the cursor over the points in the graph to see the coordinates of that point. For example, the point (0, 252.9) indicates that there were 252.9 million DVDs sold in 2008. The point (1, 234.6) indicates that there were 234.6 million DVDs sold during the year 2009, etc.

Answer



Spinners
Question

Refer to "Spinners" on the right. Use the simulator to help you answer the question below. Type your answer to the question.
The theoretical probability that the arrow will stop on any one of the six colours in the spinner shown to the right is 1/6.
As the number of spins increases, how does the percentage of times that the arrow stops on each colour relate to the theoretical probability?

Explain your answer.

SPINNERS

Peter finds a website with a simulator. The spinner below is divided into six equal-size sections, each a different colour.

When the simulation is run, the number of times the arrow stopped on each colour will display in the table, based on the number of spins selected. The value in parentheses is the percentage of times the arrow stopped on each colour for that number of spins.

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