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Structure of Observed Learning Outcomes (SOLO) Taxonomy Based Teaching on the Students' Cognitive Learning Outcome and Performance in Araling Panlipunan

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Abstract*—This study was designed and aimed to determine the relationship and effect of Structure of Observed Learning Outcomes (SOLO) Taxonomy Based Teaching on the Students Cognitive Learning Outcome and Performance. Also, it sought to find out the significant relationship between hierarchical level of SOLO taxonomy and students cognitive learning outcome in terms of knowledge acquisition. Moreover, to identify the significant difference between the level of student's performance, formative and summative assessment utilizing the hierarchical level of SOLO taxonomy were employed. The researcher employed descriptive and quantitative one-group quasi-experimental research method which utilized three sets of questionnaires to gather the data. These were two sets of five-point Likert-scale questionnaires comprising of twenty-five (25) items and twenty (20) items and with five (5) statements in every sub variable and a 50-item test. The researcher employed weighted mean, standard deviation, Pearson r correlation, and t-test to analyze and interpret the data gathered. Seventy-six (76) Grade 9 students were randomly chosen as the participants of the study. The study was conducted at Caigdal National High School during the academic year of 2024-2025. The finding revealed that level of hierarchical level of SOLO taxonomy in terms of pre-structural, unistructural, multi-structural, relational, and extended abstract was very high. The level of students' cognitive learning outcome in terms of factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge was seen to be quite high. In the level of student's performance in formative and summative test in using hierarchical level of SOLO taxonomy in terms of comprehension, problem-solving, logical reasoning, analytical, and critical thinking, the results showed moderate to very high verbal interpretation. Seemingly, the result highlighted the significant relationship between the hierarchical level of SOLO taxonomy and students' cognitive learning outcome in terms of knowledge acquisition was significant. It also found out that the significant difference between the level of student's performance in formative and summative test in using hierarchical level of SOLO taxonomy also was found to be significant. Therefore, hypotheses were rejected. Based on the findings and conclusions drawn, it is recommended that teachers are highly encouraged to use SOLO Taxonomy into their lesson planning, instructional strategies, and assessment tools to promote deeper student learning and cognitive growth and development. The school administrators actively support and promote the integration of SOLO Taxonomy (Structure of Observed Learning Outcomes) in the design of lesson plans, instructional activities, and assessments. Likely, it is essential to provide professional development opportunities for teachers to understand the SOLO framework and how to apply it in lesson design and assessment that key to enhancing students' learning experiences and outcomes.*

***Keywords*—** *SOLO taxonomy, teaching, cognitive, learning outcome, performance.*

I. INTRODUCTION

The basic framework of a quality education is one that succeeds in meeting the individual school desired goals and outcomes. It is relevant to the needs of students, communities and society.

The Structure of Observed Learning Outcomes (SOLO) framework was developed by John Biggs and Kevin Collis, two researchers who were interested in creating a framework that could help teachers design more effective learning experiences. This taxonomy suggests five SOLO levels such as: pre-structural where students' exhibit a lack of understanding, often missing the point entirely; uni-structural level is when the student can identify singular aspects of knowledge, and their understanding is limited to isolated disciplinary knowledge; multi-structural level is when the learner begin to gather multiple pieces of information, but they struggle to relate them coherently; relation level is where the student begin to connect the multi-structural elements into a coherent whole; and extended abstract level is when the students not only connect facts but extrapolate and hypothesize beyond the given context (Adeniji et al, 2022).

Cognitive learning is a metacognitive process that consists of skills and dispositions that increases the chances of producing a logical solution to a problem or a valid conclusion to an argument (Quinn et al. 2020).

Seemingly, effective teaching strategies can significantly enhance students' cognitive learning, preparing them for academic success and future professional environments. In such, lesson planning is essential for the structured delivery of curriculum content. It allows teachers to organize instructional activities, resources, and time management to optimize student engagement and learning. In addition, well-structured lesson plans enhance teacher preparedness, allowing educators to anticipate challenges and adjust to diverse student needs (Johnson, 2019). Educators continually seek innovative approaches that not only facilitate knowledge acquisition but

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also promote deeper understanding and critical thinking skills among learners. Among various pedagogical frameworks, the Structure of Observed Learning Outcomes (SOLO) taxonomy stands out as a promising model for structuring learning experiences and evaluating student learning cognitive progression.

Moreover, assessment tools are important for measuring student learning and guiding instructional decisions. They provide essential insights into student progress and highlight areas needing improvement.. Moreover, effective assessments offer students constructive feedback, aiding in the understanding of their strengths and weaknesses and promoting continuous improvement (Wilson, 2022).

According to Ambarita et al. (2019), SOLO taxonomy assessment questions are a valuable tool for educators and instructional designers who are looking to assess student learning outcomes in a more comprehensive and accurate way. Using Bloom's Taxonomy, the design questions assess a student's understanding at different levels of complexity, from basic recall to higher-order thinking skills such as analysis and synthesis.

The purpose of this research study was to use the SOLO taxonomy to examine the link between the hierarchical level of the taxonomy and students' cognitive learning outcomes, as well as the important distinction between formative and summative assessment. By integrating a structured, inquiry-based teaching approach with comprehensive assessment methods, this study sought to provide insights into how educational planning and evaluation techniques can enhance learning outcomes in Araling Panlipunan. The findings were expected to offer valuable contributions to instructional practices and assessment frameworks, ultimately supporting the development of more effective teaching methods that cater to diverse student needs and promote deeper understanding of the subject matter.

1.1 Statement of the Problem

Problem/s which were addressed by the research

This study aimed to determine the relationship and effect of Structure of Observed Learning Outcomes (SOLO) Taxonomy Based Teaching on the Students' Cognitive Learning Outcome and Performance.

Specifically, it sought to answer the following questions:

1. What is the level of Hierarchical Levels of 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 students' cognitive learning outcome in term of knowledge acquisition in terms of:
   2.1 factual knowledge;
   2.2 conceptual knowledge;
   2.3 procedural knowledge; and
   2.4 metacognitive knowledge?
3. What is the level of student's performance in formative and summative test using SOLO taxonomy in terms of:
   3.1 comprehension;
   3.2 problem-solving;
   3.3 logical reasoning;
   3.4 analytical; and
   3.5 critical thinking?
4. Is there a significant relationship between hierarchical level of SOLO taxonomy and students' cognitive learning outcome in terms of knowledge acquisition?
5. Is there a significant difference between the level of student's performance in formative and summative tests using hierarchical level of SOLO taxonomy?

II. METHODOLOGY

The researcher employed descriptive and quantitative one-group quasi-experimental research method which utilized three sets of questionnaires to gather the data. These were two sets of five-point Likert-scale questionnaires comprising of twenty-five (25) items and twenty (20) items and with five (5) statements in every sub variable and a 50-item test. The researcher employed weighted mean, standard deviation, Pearson r correlation, and t-test to analyze and interpret the data gathered. Seventy-six (76) Grade 9 students were randomly chosen as the participants of the study. The study was conducted at Caigdal National High School during the academic year of 2024-2025.

III. RESULTS AND DISCUSSION

This chapter presents, analyzes, and interprets the data collected, which revealed a strong correlation between the hierarchical level of the SOLO taxonomy and students' cognitive learning outcomes and performance

Level of Hierarchical Levels of SOLO Taxonomy

Hierarchical Levels of SOLO Taxonomy describe levels of increasing complexity in students' understanding of a subject. It provides a structured way to assess learning outcomes based on depth of understanding, moving from simple recall to higher-order thinking skills. In this study SOLO Taxonomy includes variables such as pre-structural, unistructural, multi structural, relational and extended abstract, and was statistically measured using mean and standard deviation.

Table 1 presents an evaluation of the Hierarchical Levels of SOLO Taxonomy in terms of the Pre-Structural Level. The Pre-Structural Level represents the stage where students lack understanding or fail to grasp the concept, requiring structured guidance to build foundational knowledge.

The weighted mean of 4.39 and the standard deviation of 0.63 indicate that teachers believed that step-by-step activities can gradually build understanding and eliminate learning gaps in students. This includes developing supplementary materials and using lower-order cognitive tasks such as identifying, memorizing, and recalling key concepts. Additionally, lessons should begin with low-difficulty levels, ensuring students master foundational knowledge before progressing to more

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complex ideas. This implies the importance of structured learning activities, supplementary materials, and progressive difficulty levels in helping students build foundational knowledge before moving to higher levels of cognitive learning

TABLE 1. *Level of Hierarchical Levels of SOLO Taxonomy in terms of Pre - Structural*

STATEMENT	***MEAN***	***SD***	***REMARKS***
1. Provide activities that eradicate the lack of understanding.	4.43	0.55	Strongly Agree
2. Develop supplementary materials that help students to understand the point of their lesson entirely.	4.41	0.61	Strongly Agree
3. Prepare step by step level of thinking activities to assist the learning of the students.	4.49	0.64	Strongly Agree
4. Utilize lower-order verbs such as identify, memorize, and recall.	4.32	0.64	Strongly Agree
5. Use low difficulty level that needs overcoming before progressing.	4.32	0.68	Strongly Agree
Weighted Mean	*4.39*		
SD	*0.63*		
Verbal Interpretation	*Very High*		

Table 2 shows the evaluation of the Hierarchical Levels of SOLO Taxonomy in terms of the Uni-structural level. The Uni-structural level represents a stage where learners can identify or recall one relevant aspect of a concept but have a limited understanding beyond that. At this level, knowledge is surface-level and lacks connections to other ideas.

TABLE 2. *Level of Hierarchical Levels of SOLO Taxonomy in terms of Unistructural*

STATEMENT	***MEAN***	***SD***	***REMARKS***
1. Make simple activity that enables the learners to identify singular aspects of knowledge.	4.43	0.60	Strongly Agree
2. Provide instructions that caters limited to isolated disciplinary knowledge.	4.34	0.66	Strongly Agree
3. I join in our school's organizations like being part of student council.	4.63	0.54	Strongly Agree
4. Develop supplementary activities that which provides single relevant aspect of a task or subject.	4.46	0.58	Strongly Agree
5. Make easy and apparent connections with each topic to help student fully understand their lesson.	4.45	0.64	Strongly Agree
Weighted Mean	*4.46*		
SD	*0.61*		
Verbal Interpretation	*Very High*		

A weighted mean of 4.46 with SD 0.61 for the Uni-structural level in the SOLO Taxonomy suggests that learners demonstrate a very high level of basic understanding, where they can recognize and recall a single relevant aspect of a concept. However, their understanding is likely isolated and lacks depth beyond that one idea.

This suggests that learners have a strong grasp of basic, individual concepts but may need further support to develop deeper, interconnected understanding. This can guide educators or researchers in refining instructional methods to enhance critical thinking and application skills.

Table 3 explains that in the SOLO Taxonomy, the Multi-structural level indicates that learners can identify and understand multiple aspects of a topic independently. However, they may not yet see connections between these aspects or apply them in a broader context.

A mean of 4.29 with SD 0.64 suggests that learners demonstrate a strong ability to recall and describe multiple relevant concepts related to the subject matter. This is a positive indicator of knowledge retention and awareness of key ideas.

It also suggests that learners have a strong understanding of multiple aspects of a topic but may not yet connect these ideas meaningfully. To move to the Relational level, teaching strategies should emphasize integration, comparison, and application of knowledge.

TABLE 3. *Level of Hierarchical Levels of SOLO Taxonomy in terms of multi-structural*

STATEMENT	***MEAN***	***SD***	***REMARKS***
1. Use graphic organizers and concept maps to gather multiple pieces of information.	4.34	0.64	Strongly Agree
2. Provide activities that can help students in gaining an understanding of numerous relevant independent aspects.	4.28	0.58	Strongly Agree
3. Utilize various types of learning approach to aid students in making varied connections in their lesson.	4.30	0.65	Strongly Agree
4. Make activities that enable the students to compare and contrast situation and response are based on relevant aspects.	4.32	0.68	Strongly Agree
5. Formulate questions which helps the learners analyze and think critically.	4.24	0.65	Strongly Agree
Weighted Mean	*4.29*		
SD	*0.64*		
Verbal Interpretation	*Very High*		

Table 4, the Relational level represents a stage where learners can integrate multiple aspects of a concept and see the relationships between them. They understand how different ideas connect and can apply them in a meaningful way rather than just listing facts. A weighted mean of 4.40 suggests that learners demonstrate a strong ability to connect ideas and apply their knowledge. This is a positive indicator of deeper learning, as learners are not just memorizing facts but understanding relationships between concepts.

Learners at this level can analyze, compare, and explain relationships between ideas. This suggests that instructional methods have been effective in promoting deep learning. To further enhance learning, educators can challenge learners to move toward the highest level (Extended Abstract) by encouraging them to generalize concepts, make predictions, and apply their knowledge in new situations.

Table 5 demonstrates the Extended Abstract level in the SOLO Taxonomy is the highest level of learning, where learners go beyond simply understanding and connecting ideas—they generalize, hypothesize, create, and apply their knowledge in novel ways.

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TABLE 4. *Level of Hierarchical Levels of SOLO Taxonomy in terms of Relational*

STATEMENT	MEAN	SD	REMARKS
1. Provide activities that aid the students to relate aspects of knowledge combining to form a structure.	4.43	0.60	Strongly Agree
2. Utilize multidisciplinary approach and let the learners understand the importance of different parts of their lesson in relation to the whole.	4.37	0.61	Strongly Agree
3. Provides instructions which have a coherent knowledge of the whole thing.	4.42	0.57	Strongly Agree
4. Create a task that allows the students to combine all the parts of the lesson and demonstrate how each part contributes to the whole.	4.55	0.50	Strongly Agree
5. Encourage the students to master the complexity of the subject by being able to join all the parts together.	4.24	0.54	Strongly Agree
Weighted Mean	*4.40*		
SD	*0.57*		
Verbal Interpretation	*Very High*		

TABLE 5. *Level of Hierarchical Levels of SOLO Taxonomy in terms of Extended Abstract*

STATEMENT	MEAN	SD	REMARKS
1. Allow the students to integrate whole ideas and let them conceptualize at a higher level of abstraction.	4.22	0.62	Strongly Agree
2. Let the learners transfer and generalize the concepts and principles from one subject area into a particular domain.	4.13	0.60	Strongly Agree
3. Provide tasks that allow the students to create new ideas based on their mastery of the subject.	4.30	0.65	Strongly Agree
4. Propose new concepts and ideas depending on the learners' understanding of the task or subject taught.	4.37	0.67	Strongly Agree
5. Allow the students to connect facts, extrapolate and hypothesize beyond the given context.	4.33	0.70	Strongly Agree
Weighted Mean	*4.27*		
SD	*0.65*		
Verbal Interpretation	*Very High*		

A weighted mean of 4.27 indicates that learners, on average, have achieved a high level of critical thinking and application of knowledge. This suggests that many learners can generalize concepts and apply them innovatively, which is a strong indicator of deep learning.

This implies that learners are capable of deep, critical, and creative thinking, successfully applying knowledge beyond the given context. While most learners demonstrate advanced cognitive skills, some variation exists, highlighting opportunities for further challenge and refinement.

Level of students' cognitive learning outcome

Students' cognitive learning outcome is the knowledge, understanding, and intellectual skills that students develop as a result of learning experiences. In this study students' cognitive outcomes include factual knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge, and was determine by mean and standard deviation.

Table 6 evaluates students' cognitive learning outcomes specifically in terms of factual knowledge, which refers to the fundamental knowledge of facts, terminologies, and details necessary for deeper learning.

TABLE 6. *Level of students' cognitive learning outcome in terms of Factual Knowledge*

STATEMENT	MEAN	SD	REMARKS
1. Learn through reading terminologies and specific details.	4.50	0.62	Strongly Agree
2. Understand the basic elements of knowledge through facts.	4.47	0.58	Strongly Agree
3. Able to identify what is correct and wrong statement.	4.46	0.60	Strongly Agree
4. Verify information through own understanding of the concept.	4.41	0.64	Strongly Agree
5. Interpret and give examples from the knowledge gain.	4.50	0.55	Strongly Agree
Weighted Mean	*4.47*		
SD	*0.60*		
Verbal Interpretation	*Very High*		

The results show that students demonstrate a very high level of factual knowledge acquisition, as reflected in the weighted mean of 4.47 with a standard deviation of 0.60This means that students effectively learn through reading terminologies and interpreting knowledge through examples based on acquired knowledge which serves as the foundation for higher-order thinking skills. Their ability to read, comprehend, verify, and interpret factual information ensures a strong cognitive base, supporting future learning in more complex areas.

Table 7 reveals the students' outcome in terms of conceptual knowledge goes beyond mere recall of facts and focuses on understanding relationships, principles, classifications, and theories. It allows learners to recognize patterns and relationships between ideas, understand theories, models, and frameworks, and apply concepts to different situations.

A weighted mean of 4.46 suggests that students have a strong grasp of conceptual knowledge, meaning they understand relationships between ideas and can categorize information meaningfully. This indicates effective instruction and cognitive development, where students are not just memorizing facts but making sense of broader concepts.

It also indicates that students have a strong ability to understand and relate ideas, not just memorize facts. However, to ensure higher-order cognitive development, instruction should focus on deeper application and integration of knowledge in real-world contexts.

The review discusses the organization of conceptual knowledge in semantic memory and its implications for language comprehension and production. Additionally, the authors explore how conceptual knowledge guides the interpretation of social cues, facilitates perspective-taking, and shapes communicative behavior. The review also addresses the role of conceptual knowledge in cross-cultural communication and the emergence of shared understanding in social interactions.

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TABLE 7. *Level of Students' Cognitive Learning Outcome in terms of Conceptual Knowledge*

STATEMENT	MEAN	SD	REMARKS
1. Understand the whole idea of the concept given.	4.61	0.54	Strongly Agree
2. Learn through various ways of learning technique.	4.39	0.59	Strongly Agree
3. Recognize concepts through experiential learning.	4.34	0.60	Strongly Agree
4. Able to relate concepts from one another.	4.42	0.66	Strongly Agree
5. Introduce new knowledge and connect it with the previous knowledge.	4.55	0.62	Strongly Agree
Weighted Mean	*4.46*		
SD	*0.61*		
Verbal Interpretation	*Very High*		

Table 8 presents the evaluation of students' learning outcome in terms of procedural knowledge refers to knowing how to do something, including: methods and techniques for problem-solving, processes and steps in performing tasks, application of skills and strategies in different contexts. This type of knowledge is essential for learners to move from understanding concepts to actually applying them in practice.

TABLE 8. *Level of Students' Cognitive Learning Outcome in terms of Procedural Knowledge*

STATEMENT	MEAN	SD	REMARKS
1. Perform specific skill or task through various methods.	4.28	0.64	Strongly Agree
2. Apply knowledge into hands-on experiences.	4.38	0.63	Strongly Agree
3. Achieve task appropriately with the knowledge gained.	4.45	0.57	Strongly Agree
4. Understands different procedures and able to follow it.	4.49	0.58	Strongly Agree
Know how to do things through own understanding and capabilities.	4.43	0.64	Strongly Agree
Weighted Mean	*4.41*		
SD	*0.62*		
Verbal Interpretation	*Very High*		

A weighted mean of 4.41 suggests that students demonstrate strong ability in applying knowledge through procedures, techniques, and skills. This indicates that most students can follow methods effectively and execute tasks with confidence. A very high interpretation of weighted mean in procedural knowledge suggests that students have strong abilities in applying knowledge through structured methods. However, to ensure deeper learning, they should be guided toward more independent problem-solving and self-evaluation.

Table 9 reveals the evaluation of students' cognitive learning outcome in terms of metacognitive knowledge refers to awareness, understanding, and regulation of one's own learning and thinking processes. It includes: knowledge of strategies for learning and problem-solving, awareness of personal strengths and weaknesses, and ability to plan, monitor, and evaluate one's own learning. This is the highest level of cognitive learning since it involves self-regulation and adaptability in learning.

TABLE 9. *Level of Students' Cognitive Learning Outcome in terms of Metacognitive Knowledge*

STATEMENT	MEAN	SD	REMARKS
1. Understand the knowledge about the learning itself.	4.43	0.62	Strongly Agree
2. Differentiate concepts from one another.	4.34	0.58	Strongly Agree
3. Make different ways of learning approach that can fits own learning habits.	4.46	0.60	Strongly Agree
4. Deeply learned from various knowledges and information.	4.45	0.55	Strongly Agree
5. Explain own understanding through comprehension, problem-solving, and application of learned lesson.	4.53	0.62	Strongly Agree
Weighted Mean	*4.44*		
SD	*0.59*		
Verbal Interpretation	*Very High*		

A weighted mean of 4.44 suggests that students demonstrate strong self-awareness and control over their learning strategies. This indicates that most students not only understand and apply knowledge but also reflect on how they learn and improve their approaches. High metacognitive awareness is a key factor in lifelong learning and academic success.

Teaching should focus on helping all students refine their self-regulation skills for long-term academic success. It suggests that students demonstrate strong awareness and control over their learning strategies. However, some variation exists, meaning not all students have fully mastered self-regulation techniques. To further enhance learning, educators should focus on helping students refine their ability to plan, monitor, and evaluate their learning for greater academic success.

Table 10 gleans the level of student's performance in formative in using SOLO taxonomy in terms of comprehension. Comprehension refers to the ability to grasp meaning, interpret information, and explain ideas in a structured way. A higher score generally indicates that students are moving beyond basic recall and understanding, progressing toward relational or extended abstract levels of comprehension.

TABLE 10. *Level of Student's Performance in Formative and Summative Test using SOLO taxonomy in terms of Comprehension*

Comprehension	**Pre-test**		**Post-test**		
Scores	Frequency	Percentage	Frequency	Percentage	Verbal Interpretation
9-10	8	10.53%	31	40.79%	Excellent
7-8	19	25.00%	32	42.11%	Very Good
5-6	33	43.42%	13	17.11%	Good
3-4	16	21.05%	0	0.00%	Fair
1-2	0	0.00%	0	0.00%	Poor
Total	76	100.00%	76	100.00%	
Mean	6.24		7.99		
SD	1.91		1.44		
Verbal Interpretation	High		High		

A mean score of 6.24 suggests that, on average, students demonstrate a strong level of comprehension in their formative assessments. This score likely. places students in the relational to extended abstract levels of the SOLO

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taxonomy, meaning they can connect ideas, analyze relationships, and apply concepts beyond basic understanding. It also indicates that instructional strategies effectively support deep learning and comprehension development.

Additionally, it demonstrates the degree of students' performance in summative tasks utilizing the SOLO taxonomy in terms of comprehension. A higher mean score in summative assessment suggests that students are performing at advanced levels, demonstrating deep understanding and application of concepts.

A mean score of 7.99 indicates that students, on average, demonstrate a high level of comprehension, likely within the relational or extended abstract levels of SOLO taxonomy. This suggests that students not only understand concepts but can also analyze, synthesize, and apply their knowledge effectively in summative assessments. The high performance indicates effective instruction and learning retention, as students can recall and apply concepts when tested under formal evaluation.

The increase from 6.44 (formative) to 7.99 (summative) indicates significant student growth, improved comprehension, and effective learning strategies. Students likely progressed to higher SOLO taxonomy levels, demonstrating stronger retention and application of knowledge. Moving forward, educators should continue successful instructional practices, support struggling students, and encourage deeper learning experiences to sustain academic success.

Table 11 displays the level of student's performance in formative in using SOLO taxonomy in terms of problem solving. Problem-solving ability is a crucial cognitive skill that progresses through the SOLO Taxonomy levels. A mean of 5.95 suggests that students are developing their problem-solving skills but may still struggle with making deeper connections and applications.

TABLE 11. *Level of Student's Performance in Formative and Summative Test using SOLO Taxonomy in terms of Problem Solving*

	Formative		**Summative**		
Scores	Frequency	Percentage	Frequency	Percentage	Verbal Interpretation
9-10	13	17.11%	33	43.42%	Excellent
7-8	29	38.16%	25	32.89%	Very Good
5-6	22	28.95%	18	23.68%	Good
3-4	12	15.79%	0	0.00%	Fair
1-2	0	0.00%	0	0.00%	Poor
Total	76	100.00%	76	100.00%	
Mean	5.95		8.28		
SD	1.77		1.27		
Verbal Interpretation	Moderately High		Very High		

It suggests that students are at the multi-structural to relational level in problem-solving. This means students can identify multiple aspects of a problem but may struggle with synthesizing information, analyzing relationships, or applying solutions in new contexts. Some students may require additional practice in connecting ideas and applying problem-solving strategies effectively.

On the other hand, level of student's performance in summative in using SOLO taxonomy in terms of problem-solving displays a weighted mean of 8.28 suggests that students have achieved a high level of problem-solving proficiency, likely at the relational to extended abstract levels in SOLO taxonomy. Students can integrate different aspects of problem-solving, analyze relationships, and apply solutions in various contexts. This indicates strong cognitive development and mastery of problem-solving skills.

The increase from 5.95 formative to 8.28 summative in problem-solving performance reflects strong student growth, effective teaching strategies, and deeper cognitive processing. Students likely progressed from basic understanding (multi-structural) to higher SOLO taxonomy levels (relational to extended abstract), allowing them to analyze, integrate, and apply problem-solving skills effectively. Moving forward, educators should continue reinforcing these skills through real-world applications, critical thinking activities, and personalized learning strategies.

Table 12 displays the level of student's performance in formative in using SOLO taxonomy in terms of logical reasoning. A mean score of 6.00 suggests that students have a moderate level of logical reasoning skills, likely falling between the multi-structural and relational levels of SOLO Taxonomy. This means students can identify multiple components of a logical problem but may struggle to fully integrate or apply reasoning in complex scenarios. Some students might still be at the multi-structural level, where they can recognize different aspects of logic but do not yet establish deep connections between them.

TABLE 12. *Level of Student's Performance in Formative and Summative Test using SOLO Taxonomy in terms of Logical Reasoning*

	Formative		**Summative**		
Scores	Frequency	Percentage	Frequency	Percentage	Verbal Interpretation
9-10	12	15.79%	20	26.32%	Excellent
7-8	25	32.89%	29	38.16%	Very Good
5-6	16	21.05%	27	35.53%	Good
3-4	23	30.26%	0	0.00%	Fair
1-2	0	0.00%	0	0.00%	Poor
Total	76	100.00%	76	100.00%	
Mean	6.00		7.63		
SD	1.80		1.67		
Verbal Interpretation	Moderately High		High		

It indicates that students have a moderate level of logical reasoning skills, with some demonstrating relational thinking while others remain at multi-structural levels. The high standard deviation (1.80) suggests a wide gap in student abilities, meaning some excel while others need further support. To improve logical reasoning, educators should incorporate structured problem-solving exercises, encourage justification of answers, and use guided questioning to deepen student understanding.

While, level of student's performance in summative in using SOLO taxonomy in terms of logical reasoning display a weighted mean of 7.63 suggests that students improved significantly in their logical reasoning abilities compared to their formative assessment (mean = 6.00). This score likely

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reflects students reaching the relational to extended abstract levels of the SOLO taxonomy, meaning they can analyze complex problems, identify relationships, and apply logical reasoning effectively across different contexts.

Overall, the increase from 6.00 (formative) to 7.63 (summative) in logical reasoning performance suggests strong cognitive development, with most students progressing to relational and extended abstract levels in the SOLO taxonomy. The slight reduction in SD (1.67) indicates a more consistent performance, but some variation remains. To further enhance logical reasoning, educators should continue reinforcing advanced thinking skills, address performance gaps, and challenge students with complex, real-world applications.

Table 13 exhibits the level of student's performance in formative in using SOLO taxonomy in terms of analytical. A mean of 6.24 suggests that students have a moderate level of analytical skills, likely within the multi-structural to relational levels of the SOLO taxonomy. This indicates that students can identify and describe multiple components of an analysis but may not yet fully integrate or synthesize them. Some students may still rely on basic pattern recognition and surface-level analysis rather than deep evaluation and critical assessment.

TABLE 13. *Level of Student's Performance in Formative and Summative Test using SOLO Taxonomy in terms of Analytical*

	Formative		**Summative**		
Scores	Frequency	Percentage	Frequency	Percentage	Verbal Interpretation
9-10	9	11.84%	29	38.16%	Excellent
7-8	29	38.16%	28	36.84%	Very Good
5-6	24	31.58%	19	25.00%	Good
3-4	14	18.42%	0	0.00%	Fair
1-2	0	0.00%	0	0.00%	Poor
Total	76	100.00%	76	100.00%	
Mean	6.24		8.00		
SD	1.91		1.44		
Verbal Interpretation	High		Very High		

The table also displays the result of formative test of students in analytical aspects. A mean of 8.00 indicates that students have developed strong analytical skills, likely reaching the relational to extended abstract levels of the SOLO taxonomy. This suggests that students can not only identify and describe multiple components of an analysis but also integrate, evaluate, and apply critical thinking skills to complex scenarios. Compared to the formative mean of 6.24, there is a notable improvement, demonstrating enhanced analytical reasoning and deeper cognitive processing.

The increase from 6.24 (formative) to 8.00 (summative) in analytical skills reflects strong cognitive development, with most students progressing toward relational and extended abstract levels of the SOLO taxonomy. The moderate SD (1.44) indicates more consistent performance, showing that instructional strategies were effective in improving analytical thinking. Moving forward, educators should continue reinforcing critical thinking through advanced, real-world applications while providing additional support for students who need further development.

Table 14 presents the students' cognitive learning outcome in terms of critical thinking with a mean of 6.24 suggests that students have a moderate level of critical thinking skills, likely within the multi-structural to relational levels of the SOLO taxonomy. This means that while students can identify different aspects of a problem and analyze them separately, they may struggle to connect ideas or apply critical thinking across different contexts. Some students may still rely on surface-level reasoning rather than deeper evaluation and synthesis of information.

TABLE 14. *Level of student's Performance in Formative and Summative test using SOLO Taxonomy in terms of Critical Thinking*

	Formative		**Summative**		
Scores	Frequency	Percentage	Frequency	Percentage	Verbal Interpretation
9-10	17	22.37%	42	55.26%	Excellent
7-8	21	27.63%	18	23.68%	Very Good
5-6	21	27.63%	16	21.05%	Good
3-4	17	22.37%	0	0.00%	Fair
1-2	0	0.00%	0	0.00%	Poor
Total	76	100.00%	76	100.00%	
Mean	6.24		8.00		
SD	1.91		1.44		
Verbal Interpretation	High		High		

It also reveals the summative result with a mean of 8.00 indicates that students have developed strong critical thinking skills, likely reaching the relational to extended abstract levels of the SOLO taxonomy. This suggests that students can now evaluate arguments, synthesize multiple ideas, draw logical conclusions, and apply their critical thinking to complex and real-world scenarios. The significant increase from 6.24 (formative) to 8.00 (summative) shows substantial progress, likely due to effective instructional strategies, guided practice, and deeper cognitive engagement over time.

The increase from 6.24 (formative) to 8.00 (summative) in critical thinking performance reflects strong cognitive development, with most students progressing toward the relational and extended abstract levels of the SOLO taxonomy. The moderate SD (1.44) suggests more consistent performance across students, showing that instructional strategies effectively enhanced critical thinking skills. Moving forward, educators should continue challenging students with real-world problem-solving, reflective thinking, and argumentation exercises to further refine their analytical and evaluative abilities.

Table 15 presents the correlation analysis between the Hierarchical Levels of SOLO Taxonomy and Students' Cognitive Learning Outcomes categorized into factual, conceptual, procedural, and metacognitive knowledge. The strength and direction of relationships were determined using Pearson's correlation coefficients.

TABLE 15. *Test of Relationship between Hierarchical level of SOLO Taxonomy and Students' Cognitive Learning Outcome*

Hierarchical Levels of SOLO Taxonomy		**Knowledge Acquisition**			
		Factual Knowledge	Conceptual Knowledge	Procedural Knowledge	Metacognitive Knowledge
Pre-structural	Pearson Correlation	.495***	.472***	.588***	.421***

Jennifer Balmes Velasco, "Structure of Observed Learning Outcomes (SOLO) Taxonomy Based Teaching on the Students' Cognitive Learning Outcome and Performance in Araling Panlipunan," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 7, Issue 12, pp. 344-352, 2025.

	Sig. (2-tailed)	<.001	<.001	<.001	<.001
	N	76	76	76	76
Uni-structural	Pearson Correlation	.350**	.324**	.520***	.325**
	Sig. (2-tailed)	<.01	<.01	<.001	<.01
	N	76	76	76	76
Multi-structural	Pearson Correlation	.293*	.248*	.331**	0.12
	Sig. (2-tailed)	<.05	<.05	<.01	0.303
	N	76	76	76	76
Relational	Pearson Correlation	.551***	.409***	.605***	.481***
	Sig. (2-tailed)	<.001	<.001	<.001	<.001
	N	76	76	76	76
Extended Abstract	Pearson Correlation	.375**	.346**	.456***	.325**
	Sig. (2-tailed)	<.01	<.01	<.001	<.01
	N	76	76	76	76

*Note: *p<.05, **p<.01, ***p<.001*

Pre-structural level shows significant positive correlations across all knowledge types, with the highest correlation found in procedural knowledge ($p < .001$). This means that even at the pre-structural level, students demonstrate a degree of procedural understanding, though this level typically represents minimal comprehension.

While Uni-structural level show significant correlations exist across all knowledge types, with procedural knowledge ($p < .001$) again showing the highest relationship. Correlations are slightly lower than the pre-structural level in factual and conceptual knowledge, indicating that learning at this stage may still be developing in breadth and depth.

Likewise Multi-structural Level factual, conceptual ($p < .05$) and procedural knowledge ($p < .01$) show significant but weaker correlations. Notably, metacognitive knowledge is not significantly correlated ($p > 0.05$), indicating that at this stage, students may not yet engage in deeper self-regulated learning.

Relational Level shows stronger correlations across all knowledge types, particularly with procedural knowledge, factual knowledge ($p < .001$)

Additionally Extended Abstract Level show, significant correlations are observed across all knowledge types, but procedural knowledge ($p < .001$) remains the strongest.

Metacognitive knowledge ($p < .01$) is also significant, supporting the idea that higher SOLO levels involve reflective and strategic thinking.

The findings highlight the importance of progressing through the SOLO taxonomy for improved knowledge acquisition. The results implies that students who engage in deeper learning processes relational and extended abstract levels tend to develop stronger cognitive abilities, particularly in procedural and metacognitive knowledge.

Table 16 presents a comparison of students' performance on formative and summative tests across different cognitive skills based on the hierarchical levels of the Structure of the Observed Learning Outcome (SOLO) Taxonomy. The paired-samples t-test is the statistical test employed to see if the mean scores of the two evaluations differ significantly.

Across all cognitive indicators (Comprehension, Problem Solving, Logical Reasoning, Analytical Thinking, and Critical Thinking), the mean score in the summative test is significantly higher than in the formative test. The p-values for all comparisons are 0.000, which is less than the significance level ($p < 0.05$), indicating that the observed differences are statistically significant. This means that formative assessments contribute to the learning process, preparing students to perform better in summative evaluations. These results reinforce the importance of continuous assessment in education and the role of SOLO Taxonomy in measuring different levels of student understanding.

TABLE 16. *Significant Difference between the Level of Student's Performance in Formative and Summative Test using Hierarchical level of SOLO Taxonomy*

	Formative		**Summative**			**95% CI**				
Indicator	*M*	*SD*	*M*	*SD*	Mean Difference	*L*	*U*	*T*	*df*	*P*
Comprehension	6.24	1.91	8.00	1.44	-1.76	-2.35	-1.18	-5.98	75	0.000*
Problem Solving	5.95	1.77	8.28	1.27	-2.33	-2.49	-2.16	-28.24	75	0.000*
Logical reasoning	6.00	1.80	7.63	1.67	-1.63	-1.79	-1.47	-20.07	75	0.000*
Analytical	6.24	1.91	8.00	1.44	-1.76	-2.35	-1.18	-5.98	75	0.000*
Critical thinking	6.24	1.91	8.00	1.44	-1.76	-2.35	-1.18	-5.98	75	0.000*

*Note: *p<.05.*

Students gradually develop comprehension through continuous engagement with instructional materials. The significant improvement in problem-solving skills highlights the need for multiple practice opportunities. Logical reasoning benefits from structured exercises, while analytical skills improve progressively through learning activities and feedback. Critical thinking enhances with sustained cognitive engagement, enabling students to evaluate, synthesize, and apply knowledge effectively.

IV. Conclusion and Recommendations

In light of the foregoing findings, the following conclusions were drawn from the study.

The study revealed a significant relationship between the hierarchical level of SOLO taxonomy and students' cognitive learning outcome in terms of knowledge acquisition. Thus, the researcher therefore concluded that the research hypothesis which stated that there is no significant relationship between hierarchical level of SOLO taxonomy and students' cognitive learning outcome in terms of knowledge acquisition was rejected. Likely, the second hypothesis stating that there is no

significant difference between the level of student's performance in formative and summative tests in using hierarchical level of SOLO taxonomy was also rejected.

Based on the findings and conclusions drawn, the following were recommended:

Teachers may encourage to use SOLO Taxonomy into their lesson planning, instructional strategies, and assessment tools in order to promote deeper student learning and cognitive growth and development. The SOLO Taxonomy provides a strong foundation for supporting students in moving from pre-structural through extended abstract thinking because of its structured approach to understand the wide range of learning outcomes.

By utilizing SOLO Taxonomy to engage with lesson plan activities and assessments, students may have an opportunity to systematically enhance their factual, conceptual, procedural, and metacognitive knowledge. Through a structured approach that encourages reflection and active engagement at each SOLO level, students can develop a deeper and more integrated understanding of content, improve their problem-solving abilities, and increase their capacity for learning. This holistic approach will not only help students excel in academic tasks also equip them with essential skills for lifelong learning and personal growth.

The school administrators may actively support and promote the integration of SOLO Taxonomy (Structure of Observed Learning Outcomes) in the design of lesson plans, instructional activities, and assessments. By encouraging teachers to use SOLO Taxonomy as a framework, administrators can enhance the quality of teaching and learning, which in turn can contribute to improved student performance. Likely, it is essential to provide professional development opportunities for teachers to understand the SOLO framework and how to apply it in lesson design and assessment to enhance students' learning experiences and outcomes.

As educational practices continue to evolve, future researchers may encourage to explore new ways to apply SOLO Taxonomy to diverse settings, disciplines, and learning contexts. Through these efforts, researchers can continue or adopt this research instruments, refine assessment strategies, and teaching methodologies, ultimately improving educational outcomes for students. More so, the findings of this study provide a valuable foundation for future research on SOLO Taxonomy and its impact on students' performance and their cognitive outcomes.

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