Structure of Observed Learning Outcomes (Solo) Taxonomy Based Teaching on the Students Cognitive Learning Outcome and Performance

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Abstract

The study investigated the relationship and effect of Structure of Observed Learning Outcomes (SOLO) Taxonomy Based Teaching on the Students Cognitive Learning Outcome and Performance in Science 9 at Magdalena Integrated National High School. Specifically, it aimed to determine the level of Hierarchical Levels of SOLO Taxonomy in terms of Prestructural, Unistructural, Multistructural, Relational, and Extended Abstract; the level of students cognitive learning outcome in term of knowledge acquisition in terms of Factual Knowledge, Conceptual Knowledge, Procedural knowledge, and Metacognitive Knowledge; the level of student's performance before and after using SOLO taxonomy in terms of Comprehension, Problem Solving, Logical Reasoning, Analytical, and Critical Thinking. The study also aimed to determine the significant relationship between hierarchical level of SOLO taxonomy and student's cognitive learning outcome in terms of knowledge acquisition; and the difference between the level of student's performance before and after using hierarchical level of SOLO taxonomy.

The instrument used in the study was a survey questionnaire-checklist and 50-items test. Moreover, the researcher utilized weighted mean, standard deviation, pearson r correlation, and t-test to analyze and interpret the data gathered. One hundred (100) randomly selected Grade 9students from the Magdalena Integrated National High School was assessed and used as respondents of this research. The findings shows that Hierarchical Levels of SOLO Taxonomy in terms of Prestructural, Unistructural, Multistructural, Relational, and Extended Abstract were perceived as very great extent. Similarly, students' cognitive learning outcomes in terms of knowledge acquisition, particularly in Factual, Conceptual, Procedural, and Metacognitive Knowledge, were also perceived as very great extent. Moreover, students' performance before and after using SOLO taxonomy showed a descriptive equivalent of very satisfactory across various domains, including Comprehension, Problem-Solving, Logical Reasoning, Analytical, and Critical Thinking. Importantly, a significant relationship was found between the hierarchical level of SOLO Taxonomy and students' cognitive learning outcomes, suggesting its effectiveness in facilitating knowledge acquisition. Additionally, a significant difference was observed in students' performance before and after implementing the SOLO taxonomy.

The research findings highlight a significant relationship between the hierarchical level of SOLO Taxonomy and students' cognitive learning outcomes in terms of knowledge acquisition; and significant difference in students' performance before and after implementing the SOLO taxonomy. Therefore, hypotheses were rejected. Hence, participation in this study is encouraged as it offers a comprehensive understanding of how SOLO Taxonomy enhances cognitive learning outcomes and performance. By understanding how to integrate SOLO taxonomy, teachers can enhance the teaching of Science, fostering interactive and collaborative learning environments that promote diverse skills and intelligence among students.

Keywords: Cognitive; Learning Outcomes; Performance

1. Introduction

Science is important to everyone. School Science Education should support the development of scientific literacy in all students as well as motivate them to pursue careers in science, technology, and engineering. Science is useful because of its links to technology and industry, which, from a national perspective, are areas of high priority for development. In the realm of education, the quest for effective teaching methodologies that enhance students' cognitive learning outcomes and academic performance is perennial. Educators continually seek innovative approaches that not only facilitate knowledge acquisition but 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 progression.

The Structure of Observed Learning Outcomes (SOLO) taxonomy, pioneered by John B. Biggs and Kevin F. Collis, offers a systematic framework for assessing the complexity of students' understanding and the depth of their cognitive processing. Unlike traditional assessment methods that focus solely on the quantity of correct responses, the Structure of Observed Learning Outcomes (SOLO) taxonomy emphasizes the quality of students' responses and their ability to integrate knowledge, make connections, and demonstrate higher-order thinking skills. By delineating five levels of understanding – Prestructural, Unistructural, Multistructural, Relational, and Extended Abstract – the SOLO taxonomy provides educators with a nuanced tool to design instructional strategies that scaffold students' learning journey towards deeper levels of comprehension and sophistication.

The integration of Structure of Observed Learning Outcomes (SOLO) taxonomy into teaching practices holds immense potential to transform the educational landscape by fostering meaningful learning experiences and cultivating students' intellectual growth. By aligning instructional objectives with the cognitive demands of each SOLO level, educators can tailor their teaching methods to suit diverse learning needs and optimize learning outcomes. Moreover, the explicit focus on developing students' higher-order thinking skills equips them with the analytical prowess and problem-solving abilities necessary for success in an ever-evolving knowledge economy. Structure of Observed Learning Outcomes (SOLO) taxonomy is based upon the processes of understanding used by the learners while responding to the prompts. Therefore, knowledge integrates across each level of the taxonomy. Through a comprehensive exploration of the relationship and effect between SOLO taxonomy-based teaching and students' cognitive learning outcomes and performance, this research endeavors to offer practical insights and evidence-based recommendations to educators. By harnessing the potential of SOLO taxonomy as a pedagogical tool, educators can empower students to become active, engaged learners capable of navigating the complexities of the modern world with confidence and competence.

1.1 Statement of the Problem

Specifically, it sought to answer the following questions:

1. What is the level of Hierarchical Levels of SOLO Taxonomy in terms of:
    1.1 prestructural;
    1.2 unistructural;
    1.3 multistructural;

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 significant difference between the level of student's performance in formative and summative test using hierarchical level of SOLO taxonomy?

2. Methodology

To achieve the purpose of the study, the researcher utilized the descriptive survey method of research with a self-made questionnaire as the main data-gathering instrument. Descriptive survey study is a method of research which concerns itself with the present phenomena in terms of conditions, practices, beliefs, processes, relationships or trends. It is concerned not only with the characteristics of individuals but with the characteristics of the whole sample thereof. It provides information useful to the solutions of local issues (problems).

3. Results and Discussion

This chapter presents the result, analysis, and interpretation of data gathered that examined the relationship and effect of Structure of Observed Learning Outcomes (SOLO) taxonomy based teaching on the students cognitive learning outcome and performance.

Table 1. Hierarchical Levels of SOLO Taxonomy in terms of Prestructural

STATEMENTS	MEAN	SD	REMARKS
Provide activities that eradicate the lack of understanding.	4.57	0.50	Strongly Agree
Develop supplementary materials that help students to understand the point of their lesson entirely.	4.51	0.50	Strongly Agree
Prepare step by step level of thinking	4.36	0.70	Strongly

activities to assist the learning of the students.			Agree
Utilize lower-order verbs such as identify, memorize, and recall.	4.45	0.67	Strongly Agree
Use low difficulty level that needs overcoming before progressing.	4.62	0.49	Strongly Agree
Weighted Mean **SD** **Verbal Interpretation**	4.50 0.20 Very Great Extent		

Table 1 illustrates the Hierarchical Levels of SOLO taxonomy in terms of prestructural.

The SOLO taxonomy employs a hierarchical structure where students encountered low difficulty level that needs overcoming before progressing further, with a mean score of 4.62. Additionally, it involves developing step by step level of thinking activities to aid students in their learning process, with a mean score of 4.36. It depicts the value of the SOLO taxonomy in supporting student learning and indicate potential areas for further refinement in instructional practices.

The Hierarchical Levels of SOLO taxonomy in terms of prestructural attained a weighted mean score of 4.50 and a standard deviation of 0.20 and was Very Great Extent among the respondents. This suggests that efforts to establish foundational knowledge and understanding are widely regarded as crucial in supporting students' cognitive development and academic growth.

Atherton (2013) described that students simply acquire bits of information which has no sensible connection and organization. Students have no understanding and only use information in irrelevant or insensible manner. They may have acquired scattered pieces of information but it remains unorganized, unstructured, and irrelevant to an actual topic or problem.

Table 2. Hierarchical Levels of SOLO Taxonomy in terms of Unistructural

STATEMENTS	**MEAN**	**SD**	**REMARKS**
Make simple activity that enables the learners to identify singular aspects of knowledge.	4.64	0.48	Strongly Agree
Provide instructions that caters limited to isolated disciplinary knowledge.	4.34	0.68	Strongly Agree
Make instructions that can indicates a concrete understanding of the task.	4.55	0.50	Strongly Agree
Develop supplementary activities that which provides single relevant aspect of a task or subject.	4.59	0.49	Strongly Agree
Make easy and apparent connections with each topic to help student fully understand their lesson.	4.50	0.50	Strongly Agree
Weighted Mean **SD** **Verbal Interpretation**	4.52 0.19 Very Great Extent		

Table 2 demonstrates the Hierarchical Levels of SOLO Taxonomy in terms of Unistructural.

The SOLO taxonomy demonstrates a hierarchical structure that enable learners to identify individual components of knowledge, as evidenced by the highest mean score of 4.64, indicating a very great extent of agreement. On the other hand, while providing instructions limited to isolated disciplinary knowledge received a lower mean score of 4.34, it still garnered a very great extent rating. This suggests that while teachers recognize the importance of providing instructions that cater to specific disciplinary knowledge, they may perceive activities focusing on singular aspects of knowledge as more effective in promoting deeper understanding and engagement among learners.

The Hierarchical Levels of SOLO taxonomy in terms of unistructural reached a weighted mean score of 4.52 and a standard deviation of 0.19 and was Very Great Extent among the respondents. This underscores the significance of tasks and activities that enable students to grasp and work with singular aspects of knowledge, laying the groundwork for deeper understanding and cognitive development.

Table 3. Hierarchical Levels of SOLO Taxonomy in terms of Multistructural

STATEMENTS	MEAN	SD	REMARKS
Use graphic organizers and concept maps to gather multiple pieces of information.	4.54	0.50	Strongly Agree
Provide activities that can help students in gaining an understanding of numerous relevant independent aspects.	4.56	0.50	Strongly Agree
Utilize various types of learning approach to aid students in making varied connections in their lesson.	4.59	0.49	Strongly Agree
Make activities that enable the students to compare and contrast situation and response are based on relevant aspects.	4.34	0.62	Strongly Agree
Formulate questions which helps the learners analyze and think critically.	4.37	0.65	Strongly Agree
Weighted Mean	4.48		
SD	0.17		
Verbal Interpretation	Very Great Extent		

Table 3 shows the Hierarchical Levels of SOLO Taxonomy in terms of Multistructural.

The SOLO taxonomy employs a hierarchical structure where teachers highly value the utilization of diverse learning approaches to facilitate student learning experiences, as evidenced by the highest mean score of 4.59, indicating a very great extent of agreement. This indicates a recognition of the importance of incorporating multiple instructional strategies to foster varied connections and deeper understanding among students. Conversely, while making activities that enable students to compare and contrast situations received a lower mean score of 4.34, it still received a very great extent rating. This suggests that while educators acknowledge the significance of activities focused on comparison and contrast, they may perceive the utilization of diverse learning approaches as slightly more effective in promoting holistic learning experiences.

The Hierarchical Levels of SOLO taxonomy in terms of multistructural achieved a weighted mean score of 4.48 and a standard deviation of 0.17 and was Very Great Extent among the respondents. This highlights the significance of tasks and activities that enable students to understand and work with multiple aspects of knowledge in a cohesive manner, promoting deeper comprehension and integration of concepts.

Brandbrand and Dahl (2019) explained that students can deal with several aspects but they have not established any connection between these aspects and consider them as independent aspects only. This can be metaphorically illustrated through the analogy that students might see many trees, but not the forest. Some of the operations are enumerating, describing, classifying, combining, applying methods, structuring, and executing procedures.

Table 4. Hierarchical Levels of SOLO Taxonomy in terms of Relational

STATEMENTS	MEAN	SD	REMARKS
Provide activities that aid the students to relate aspects of knowledge combining to form a structure.	4.72	0.45	Strongly Agree
Utilize multidisciplinary approach and let the learners understand the importance of different parts of their lesson in relation to the whole.	4.65	0.48	Strongly Agree
Provides instructions which have a coherent knowledge of the whole thing.	4.69	0.46	Strongly Agree
Create a task that allows the students to combine all the parts of the lesson, and demonstrate how each part contributes to the whole.	4.49	0.61	Strongly Agree
Encourage the students to mastered the complexity of the subject by being able to join all the parts together.	4.70	0.46	Strongly Agree
Weighted Mean **SD** **Verbal Interpretation**	4.65 0.23 Very Great Extent		

Table 4 proves the Hierarchical Levels of SOLO Taxonomy in terms of Relational.

The SOLO taxonomy employs a hierarchical structure where students highly value activities that facilitate the integration of various aspects of knowledge into a cohesive structure, as evidenced by the highest mean score of 4.72, indicating a very great extent of agreement. Conversely, while creating tasks that allow students to demonstrate how each part of the lesson contributes to the whole received a slightly lower mean score of 4.49, it still garnered a very great extent rating. It underscores the importance of providing opportunities for students to engage in activities that foster the synthesis of knowledge, enabling them to develop a deeper and more interconnected understanding of the content.

The Hierarchical Levels of SOLO Taxonomy in terms of Relational accomplished a weighted mean score of 4.65 and a standard deviation of 0.23 and was Very Great Extent among the respondents. This highlights the significance of tasks and activities that enable students to integrate and relate multiple aspects of knowledge, promoting deeper understanding and the ability to make meaningful connections across different concepts and domains.

Table 5. Hierarchical Levels of SOLO Taxonomy in terms of Extended Abstract

STATEMENTS	MEAN	SD	REMARKS

Allow the students to integrate whole ideas and let them conceptualized at a higher level of abstraction.	4.61	0.49	Strongly Agree
Let the learners transfer and generalize the concepts and principles from one subject area into a particular domain.	4.65	0.48	Strongly Agree
Provide tasks that allow the students to create new ideas based on their mastery of the subject.	4.51	0.67	Strongly Agree
Propose new concepts and ideas depending on the learners' understanding of the task or subject taught.	4.40	0.77	Strongly Agree
Allow the students to connect facts, extrapolate and hypothesize beyond the given context.	4.62	0.49	Strongly Agree
Weighted Mean **SD** **Verbal Interpretation**	4.56 0.28 Very Great Extent		

Table 5 displays the Hierarchical Levels of SOLO Taxonomy in terms of Extended Abstract. The SOLO taxonomy employs a hierarchical structure where educators highly value activities that promote the transfer and generalization of concepts and principles across different subject areas, as evidenced by the highest mean score of 4.65, indicating a very great extent. Additionally, proposing new concepts and ideas based on learners' understanding received a slightly lower mean score of 4.40, it still received a very great extent rating. This illustrates the importance of providing opportunities for students to transfer and apply their learning to diverse contexts, fostering deeper understanding and the development of transferable skills.

The Hierarchical Levels of SOLO taxonomy in terms of extended abstract conquered a weighted mean score of 4.56 and a standard deviation of 0.28 and was Very Great Extent among the respondents. This highlights the significance of tasks and activities that enable students to apply their learning in novel and complex contexts, promoting deeper understanding, critical thinking, and the ability to transfer knowledge to new situations.

Table 6. Level of Students' Cognitive Learning Outcome in terms of Knowledge Acquisition as to Factual Knowledge

STATEMENTS	MEAN	SD	REMARKS
Learn through reading terminologies and specific details.	4.80	0.40	Strongly Agree
Understand the basic elements of knowledge through facts.	4.61	0.49	Strongly Agree
Able to identify what is correct and wrong statement.	4.79	0.41	Strongly Agree
Verify information through own understanding of the concept.	4.83	0.38	Strongly Agree
Interpret and give examples from the knowledge gain.	4.87	0.34	Strongly Agree

Weighted Mean	4.78
SD	0.20
Verbal Interpretation	Very Great Extent

Table 6 exhibits the Level of Students' Cognitive Learning Outcome in terms of Knowledge Acquisition as to Factual Knowledge.Findings suggests that educators highly value activities that require students to interpret and provide examples based on their gained knowledge, as evidenced by the highest mean score of 4.87, indicating a very great extent. Conversely, while understanding the basic elements of knowledge through facts received a slightly lower mean score of 4.61, it still garnered a very great extent rating. These findings underscore the importance of providing opportunities for students to engage in activities that promote interpretation, analysis, and application of knowledge, as these skills are essential for meaningful learning and real-world problem-solving.

The level of students cognitive learning outcome in terms of knowledge acquisition as to factual knowledge attained a weighted mean score of 4.78 and a standard deviation of 0.20 and was Very Great Extent among the respondents. This underscores the importance of grasping foundational concepts and factual information as a crucial aspect of cognitive development and academic achievement.

Table 7. Level of Students' Cognitive Learning Outcome in terms of Knowledge Acquisition as to Conceptual Knowledge

STATEMENTS	MEAN	SD	REMARKS
Understand the whole idea of the concept given.	4.67	0.47	Strongly Agree
Learn through various ways of learning technique.	4.60	0.49	Strongly Agree
Recognize concepts through experiential learning.	4.74	0.44	Strongly Agree
Able to relate concepts from one another.	4.58	0.50	Strongly Agree
Introduce new knowledge and connect it with the previous knowledge.	4.71	0.46	Strongly Agree
Weighted Mean	4.66		
SD	0.24		
Verbal Interpretation	Very Great Extent		

Table 7 verifies the Level of Students' Cognitive Learning Outcome in terms of Knowledge Acquisition as to Conceptual Knowledge. Findings suggests that educators highly value activities that allow students to recognize concepts through experiential learning, as evidenced by the highest mean score of 4.74, indicating a very great extent of agreement. On the other hand, while learning through various learning techniques received a slightly lower mean score of 4.60, it still garnered a very great extent rating. Overall, these findings underscore the importance of incorporating experiential learning opportunities into instructional practices, as they are highly valued by educators for fostering conceptual understanding and promoting active engagement in the learning process.

The level of students' cognitive learning outcome in terms of knowledge acquisition as to conceptual knowledge reached a weighted mean score of 4.66 and a standard deviation of 0.24 and was Very Great

Extent among the respondents. It shows the importance of grasping abstract concepts and understanding the underlying principles as essential components of cognitive development and academic achievement.

Table 8. Level of Students' Cognitive Learning Outcome in terms of Knowledge Acquisition as to Procedural Knowledge

STATEMENTS	MEAN	SD	REMARKS
Perform specific skill or task through various methods.	4.72	0.45	Strongly Agree
Apply knowledge into hands-on experiences.	4.66	0.48	Strongly Agree
Achieve task appropriately with the knowledge gained.	4.60	0.53	Strongly Agree
Understands different procedures and able to follow it.	4.75	0.44	Strongly Agree
Know how to do things through own understanding and capabilities.	4.68	0.49	Strongly Agree
Weighted Mean **SD** **Verbal Interpretation**	4.69 0.18 Very Great Extent		

Table 8 illustrates the Level of Students' Cognitive Learning Outcome in terms of Knowledge Acquisition as to Procedural Knowledge. Findings suggests that educators highly value students' ability to understand and follow different procedures, as evidenced by the highest mean score of 4.75, indicating a very great extent of agreement. Additionally, while achieving tasks appropriately with the knowledge gained received a slightly lower mean score of 4.60, it still garnered a very great extent rating. Overall, these findings underscore the importance of developing both procedural knowledge and the ability to apply learned knowledge effectively in real-world tasks, as both aspects are highly valued by educators for promoting meaningful learning experiences and academic achievement.

The level of students' cognitive learning outcome in terms of knowledge acquisition as to procedural knowledge achieved a weighted mean score of 4.69 and a standard deviation of 0.18 and was Very Great Extent among the respondents. This illustrates the importance of understanding and being able to follow procedures as essential components of cognitive development and academic achievement.

Table 9. Level of Students Cognitive Learning Outcome in terms of Knowledge Acquisition as to Metacognitive Knowledge

STATEMENTS	MEAN	SD	REMARKS
Understand the knowledge about the learning itself.	4.65	0.48	Strongly Agree
Differentiate concepts from one another.	4.60	0.49	Strongly Agree
Make different ways of learning approach that can fits own learning habits.	4.68	0.47	Strongly Agree
Deeply learned from various knowledge and information.	4.70	0.46	Strongly Agree

Explain own understanding through comprehension, problem-solving, and application of learned lesson.	4.73	0.45	Strongly Agree
Weighted Mean **SD** **Verbal Interpretation**	4.68 0.22 Very Great Extent		

Table 9 demonstrates the Level of Students' Cognitive Learning Outcome in terms of Knowledge Acquisition as to Metacognitive Knowledge. Findings suggests that educators highly value students' ability to articulate their understanding through comprehension, problem-solving, and application of learned lessons, as evidenced by the highest mean score of 4.73, indicating a very great extent of agreement. Conversely, while differentiating concepts from one another received a slightly lower mean score of 4.60, it still garnered a very great extent rating. Overall, these findings underscore the importance of providing opportunities for students to demonstrate their comprehension, problem-solving skills, and application of learned lessons, as these abilities are highly valued by educators for promoting deep understanding and meaningful learning experiences.

The level of students' cognitive learning outcome in terms of knowledge acquisition as to metacognitive knowledge accomplished a weighted mean score of 4.68 and a standard deviation of 0.22 and was Very Great Extent among the respondents. This highlight the importance of developing students' awareness and understanding of their own learning processes and strategies, which are essential components of cognitive development and academic achievement.

The following table exhibits the presentation, analysis, and interpretation of data pertaining to student's performance, we delve into a multifaceted exploration of their cognitive abilities and academic achievements across diverse domains like Comprehension, Problem-Solving, Logical Reasoning, Analytical, and Critical Thinking. Comprehension stands as a cornerstone, reflecting students' ability to grasp and interpret complex information effectively. Problem-solving skills showcase their capacity to apply knowledge and strategies to overcome challenges and achieve desired outcomes. Logical reasoning entails the ability to analyze information, draw logical conclusions, and make sound judgments based on evidence. Analytical skills highlight students' proficiency in breaking down complex problems or tasks into manageable components and systematically evaluating them. Critical thinking emerges as a hallmark of intellectual prowess, encompassing the capacity to question assumptions, evaluate arguments, and construct well-reasoned opinions. Through meticulous examination and interpretation of data related to these performance indicators, researcher aim to gain deeper insights into students' cognitive development, academic growth, and readiness for the challenges of the contemporary world. It was statistically measured using mean and standard deviation.

Table 10. Level of Student's Performance in Formative & Summative in terms of Comprehension

Score	**Formative**		**Summative**		**Descriptive Equivalent**
	f	**%**	**F**	**%**	
9 – 10	12	12.00	32	32.00	Outstanding
7 – 8	31	31.00	47	47.00	Very Satisfactory
5 – 6	29	29.00	21	21.00	Satisfactory
3 – 4	28	28.0	0	0.00	Fairly Satisfactory

1 – 2	0	0.00	0	0.00	Did not meet Expectation
Total	**100**	***100***	**100**	***100***	
Weighted Mean	*5.98*		*7.71*		
SD	*1.985*		*1.169*		
Verbal Interpretation	*Satisfactory*		*Very Satisfactory*		

Table 10 proves the level of student's performance in formative in using SOLO taxonomy in terms of comprehension. Out of total number of one hundred respondents "7 to 8" received the highest frequency of thirty-one (31) or 31.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "5 to 6" received the frequency of twenty-nine (29) or 29.00% of the total population with descriptive equivalent of Satisfactory**.** While the scores "9 to 10" received the lowest frequency of twelve (12) or 12.00% of the total population with descriptive equivalent of Outstanding. Overall, the weighted mean of 5.98 and a standard deviation of 1.985 suggest a generally satisfactory level of performance, indicating that there is room for improvement but also acknowledging areas of strength in students' comprehension skills prior to the implementation of the SOLO taxonomy.

It also shows the level of student's performance in summative in using SOLO taxonomy in terms of comprehension. Out of total number of one hundred respondents "7 to 8" received the highest frequency of forty-seven (47) or 47.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "9 to 10" received the frequency of thirty-two (32) or 32.00% of the total population with descriptive equivalent of Outstanding**.** While the scores "5 to 6" received the lowest frequency of twenty-one (21) or 21.00% of the total population with descriptive equivalent of *Satisfactory*. Overall, the weighted mean of 7.71 and a standard deviation of 1.169 suggest a very satisfactory level of performance after the implementation of the SOLO taxonomy, indicating a substantial improvement in students' comprehension skills.

Table 11. Level of Student's Performance in Formative & Summative in terms of Problem solving

Score	**Formative**		**Summative**		**Descriptive Equivalent**
	f	**%**	**F**	**%**	
9 – 10	13	13.00	32	32.00	Outstanding
7 – 8	30	30.00	54	54.00	Very Satisfactory
5 – 6	31	31.00	14	14.00	Satisfactory
3 – 4	26	26.00	0	0.00	Fairly Satisfactory
1 – 2	0	0.00	0	0.00	Did not meet Expectation
Total	**100**	***100***	**100**	***100***	
Weighted Mean	6.09		7.82		
SD	1.955		1.09		
Verbal Interpretation	*Satisfactory*		*Very Satisfactory*		

Table 11 displays the level of student's performance in formative in using SOLO taxonomy in terms of problem solving. Out of total number of one hundred respondents "5 to 6" received the highest frequency of thirty-one (31) or 31.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "7 to 8" received the frequency of thirty (30) or 30.00% of the total population with descriptive equivalent of Satisfactory**.** While the scores *"*9 to 10" received the lowest frequency of thirteen (13) or 13.00% of the total population with descriptive equivalent of Outstanding. Overall, the weighted mean of 6.09 and a standard deviation of 1.955 suggest a satisfactory level of performance, indicating that there is room for improvement in students' problem-solving skills prior to the implementation of the SOLO taxonomy.

It also displays the level of student's performance in summative in using SOLO taxonomy in terms of problem solving. Out of total number of one hundred respondents "7 to 8" received the highest frequency of fifty-four (54) or 54.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "9 to 10" received the frequency of thirty-four (34) or 34.00% of the total population with descriptive equivalent of Outstanding**.** While the scores "5 to 6" received the lowest frequency of fourteen (14) or 14.00% of the total population with descriptive equivalent of Satisfactory. Overall, the weighted mean of 7.82 and a standard deviation of 1.09 suggest a very satisfactory level of performance after the implementation of the SOLO taxonomy, indicating a substantial improvement in students' problem-solving skills.

This is reinforced by the study which states that one important objectives of mathematics education are the acquisition of learning skills how to maintain problems. Problem solving is an attempt to achieve the desired goal and not automatically known the right way for that purpose. Problem solving is a cognitive process to

Table 12. Level of Student's Performance in Formative & Summative in terms of Logical reasoning

Score	**Formative**		**Summative**		**Descriptive Equivalent**
	f	**%**	**f**	**%**	
9 – 10	16	16.0	36	36.0	Outstanding
		0		0	
7 – 8	27	27.0	48	48.0	Very Satisfactory
		0		0	
5 – 6	27	27.0	16	16.0	Satisfactory
		0		0	
3 – 4	30	30.0	0	0.00	Fairly Satisfactory
		0			
1 – 2	0	0.00	0	0.00	Did not meet Expectation
Total	**100**	**100**	**100**	**100**	
Weighted Mean	6.02		7.86		
SD	2.078		1.123		
Verbal Interpretation	*Satisfactory*		*Very Satisfactory*		

Table 12 verifies the level of student's performance in formative in using SOLO taxonomy in terms of logical reasoning. Out of total number of one hundred respondents "3 to 4" received the highest frequency of thirty (30) or 30.00% of the total population with descriptive equivalent of Fairy Satisfactory. The scores "5 to 6" and "7 o 8" received the frequency of twenty-seven (27) or 27.00% of the total population with descriptive equivalent of Satisfactory and Very Satisfactory**.** While the scores *"9 to 10"* received the lowest frequency of sixteen (16) or 16.00% of the total population with descriptive equivalent of Outstanding.

Overall, the weighted mean of 6.02 and a standard deviation of 2.078 suggest a satisfactory level of performance, indicating that there is room for improvement in students' logical reasoning skills prior to the implementation of the SOLO taxonomy. The table also verifies the level of student's performance in summative in using SOLO taxonomy in terms of logical reasoning. Out of total number of one hundred respondents "7 to 8" received the highest frequency of forty-eight (48) or 48.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "9 to 10" received the frequency of thirty-six (36) or 36.00% of the total population with descriptive equivalent of Outstanding**.** While the scores "5 to 6" received the lowest frequency of sixteen (16) or 16.00% of the total population with descriptive equivalent of Satisfactory. Overall, the weighted mean of 7.86 and a standard deviation of 1.123 suggest a very satisfactory level of performance after the implementation of the SOLO taxonomy, indicating a substantial improvement in students' logical reasoning skills.

Table 13. Level of Student's Performance in Formative & Summative in terms of Analytical

Score	**Formative**		**Summative**		**Descriptive Equivalent**
	f	**%**	**f**	**%**	
9 – 10	15	15.00	32	32.00	Outstanding
7 – 8	37	37.00	55	55.00	Very Satisfactory
5 – 6	26	26.00	13	13.00	Satisfactory
3 – 4	22	22.00	0	0.00	Fairly Satisfactory
1 – 2	0	0.00	0	0.00	Did not meet Expectation
Total	**100**	**100**	**100**	**100**	
Weighted Mean	6.36		7.90		
SD	1.921		1.063		
Verbal Interpretation	*Satisfactory*		*Very Satisfactory*		

Table 13 exhibits the level of student's performance in formative in using SOLO taxonomy in terms of analytical. Out of total number of one hundred respondents "7 to 8" received the highest frequency of thirty-seven (37) or 37.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "5 to 6" received the frequency of twenty-six (26) or 26.00% of the total population with descriptive equivalent of Satisfactory**.** While the scores "9 to 10" received the lowest frequency of fifteen (15) or 15.00% of the total population with descriptive equivalent of Outstanding. Overall, the weighted mean of 6.36 and a standard deviation of 1.921 suggest a satisfactory level of performance, indicating that there is room for improvement in students' analytical skills prior to the implementation of the SOLO taxonomy.

It also exhibits the level of student's performance in summative in using SOLO taxonomy in terms of analytical. Out of total number of one hundred respondents "7 to 8" received the highest frequency of fifty-five (55) or 55.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "9 to 10" received the frequency of thirty-two (32) or 32.00% of the total population with descriptive equivalent of Outstanding**.** While the scores "5 to 6" received the lowest frequency of thirteen (13) or 13.00% of the total population with descriptive equivalent of Satisfactory. Overall, the weighted mean of 7.90 and a standard deviation of 1.063 suggest a very satisfactory level of performance after the implementation of the SOLO taxonomy, indicating a substantial improvement in students' analytical skills.

Table 14. Level of Student's Performance in Formative & Summative in terms of Critical Thinking

Score	Before		After		Descriptive Equivalent
	f	%	f	%	
9 – 10	15	15.00	32	32.00	Outstanding
7 – 8	27	27.00	52	52.00	Very Satisfactory
5 – 6	34	34.00	16	16.00	Satisfactory
3 – 4	24	24.00	0	0.00	Fairly Satisfactory
1 – 2	0	0.00	0	0.00	Did not meet Expectation
Total	**100**	**100**	**100**	**100**	
Weighted Mean	6.20		7.81		
SD	1.955		1.12		
Verbal Interpretation	*Satisfactory*		*Very Satisfactory*		

Table 14 presents the level of student's performance in formative in using SOLO taxonomy in terms of critical thinking. Out of total number of one hundred respondents "5 to 6" received the highest frequency of thirty-four (34) or 34.00% of the total population with descriptive equivalent of Satisfactory. The scores "7 to 8" received the frequency of twenty-seven (27) or 27.00% of the total population with descriptive equivalent of Very Satisfactory**.** While the scores "9 to 10" received the lowest frequency of fifteen (15) or 15.00% of the total population with descriptive equivalent of Outstanding. Overall, the weighted mean of 6.20 and a standard deviation of 1.955 suggest a satisfactory level of performance, indicating that there is room for improvement in students' critical thinking skills prior to the implementation of the SOLO taxonomy.

It also presents the level of student's performance in summative in using SOLO taxonomy in terms of critical thinking. Out of total number of one hundred respondents "7 to 8" received the highest frequency of fifty-two (52) or 52.00% of the total population with descriptive equivalent of Very Satisfactory. The scores "9 to 10" received the frequency of thirty-two (32) or 32.00% of the total population with descriptive equivalent of Outstanding**.** While the scores "5 to 6" received the lowest frequency of sixteen (16) or 16.00% of the total population with descriptive equivalent of Satisfactory. Overall, the weighted mean of 7.81 and a standard deviation of 1.12 suggest a very satisfactory level of performance after the implementation of the SOLO taxonomy, indicating a substantial improvement in students' critical thinking skills.

Table 15. Significant Relationship Between the Hierarchical level of SOLO Taxonomy and Students' Cognitive Learning Outcome in terms of Knowledge Acquisition

		Factual knowledge	Conceptual knowledge	Procedural knowledge	Metacognitive knowledge
Prestructural	Pearson Correlation	.009*	.127*	.067*	.022*

	Sig. (2-tailed)	.000	.000	.000	.000
	N	99	99	99	99
	Strength	*Very Weak*	*Very Weak*	*Very Weak*	*Very Weak*
	Analysis	*Significant*	*Significant*	*Significant*	*Significant*
Unistructural	Pearson Correlation	.134*	.348*	.143*	.220*
	Sig. (2-tailed)	.000	.000	.000	.000
	N	99	99	99	99
	Strength	*Moderate*	*Weak*	*Very Weak*	*Weak*
	Analysis	*Significant*	*Significant*	*Significant*	*Significant*
Multistructural	Pearson Correlation	.108*	.138*	.046*	.017*
	Sig. (2-tailed)	.000	.000	.000	.000
	N	99	99	99	99
	Strength	*Very Weak*	*Weak*	*Very Weak*	*Very Weak*
	Analysis	*Significant*	*Significant*	*Significant*	*Significant*
Relational	Pearson Correlation	.269*	.004*	.196	.151
	Sig. (2-tailed)	.000	.765	.232	.522
	N	20	20	20	20
	Strength	*Weak*			
	Analysis	*Significant*	*NS*	*NS*	*NS*
Extended Abstract	Pearson Correlation	.019*	.217*	.076*	.390
	Sig. (2-tailed)	.000	.013	.000	.007
	N	99	99	99	99
	Strength	*Very Weak*	*Weak*	*Very Weak*	*Weak*
	Analysis	*Significant*	*Significant*	*Significant*	*Significant*

Scale	**Strength**
0.80 – 1.00	Very Strong

0.60 – 0.79	Strong
0.40 – 0.59	Moderate
0.20 – 0.39	Weak
0.00 – 0.19	Very Weak

Table 15 demonstrates the significant relationship between the Hierarchical level of SOLO Taxonomy and Students' Cognitive Learning Outcome in terms of Knowledge Acquisition.

The Hierarchical Levels of SOLO taxonomy was observed to have a significant relationship to the students cognitive learning outcome in terms of knowledge acquisition. This is based on the computed r values obtained from the tests with very weak to moderate relationship. Furthermore, the p-values obtained were less than the significance alpha 0.05, hence there is a significance.

Overall, the analysis of the p-values indicates that the relationships between different types of knowledge and SOLO levels vary in terms of their statistical significance. While most correlations are significant, there are instances, particularly at the relational level, where the relationships may not be significant. These findings provide valuable insights into the nature of students' understanding and the associations between different types of knowledge and levels of cognitive complexity.

Table 16. Test of Difference between the level of Student's Performance in Formative & Summative in using Hierarchical Level of SOLO Taxonomy

SOLO Taxonomy	**Before**		**After**		Mean Difference	95% Confidence Interval of Difference		**T**	**df**	**Sig (2-tailed)**
	Mn	**SD**	**Mn**	**SD**		**L**	**U**			
Performance	30.64	2.64	39.11	2.06	8.47	0.25	0.61	34.09	198	0.000

*Legend: *Significant at 0.05*

The table presents the results of a test of difference between the levels of student's performance in formative and summative test using the Hierarchical Level of SOLO Taxonomy. Before implementing the SOLO Taxonomy approach, the mean performance score was 30.64 with a standard deviation of 2.64. After the intervention, the mean performance score increased to 39.11 with a standard deviation of 2.06. The mean difference between the before and after scores was 8.47, with a 95% confidence interval ranging from 0.61 to 34.09. The calculated t-value was 0.25, with 198 degrees of freedom, and the significance level (2-tailed) was found to be 0.000, indicating a highly significant improvement in performance after implementing the SOLO Taxonomy approach. This implies that the use of the SOLO Taxonomy framework for both formative and summative assessments led to a substantial enhancement in student's performance levels. The results underscore the effectiveness of the SOLO Taxonomy in facilitating deeper understanding and cognitive development among students, highlighting its potential as a valuable tool for educational assessment and instruction.

The result implies that implementing the Hierarchical Level of SOLO Taxonomy in both formative and summative assessments led to a significant improvement in student's performance levels. This suggests that using the SOLO Taxonomy framework effectively facilitates deeper understanding and cognitive development among students. By structuring assessments according to the SOLO Taxonomy's hierarchical

levels, educators can better identify students' current levels of understanding and tailor instruction accordingly.

4. Conclusion and Recommendation

On the basis of the foregoing findings, the following conclusion were drawn.

The study shows significant relationship between the hierarchical level of SOLO taxonomy and students' cognitive learning outcome in terms of knowledge acquisition. Thus, the researcher therefore concludes that the research hypotheses stating that there is no significant relationship between hierarchical level of SOLO taxonomy and students' cognitive learning outcome in terms of knowledge acquisition was rejected. On the other hand, the second hypothesis stating that there is no significant difference between the level of student's performance in formative and summative test in using hierarchical level of SOLO taxonomy was also rejected.

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

1. Its recommend that students engage with this study as it offers a comprehensive understanding of the impact of SOLO Taxonomy on enhancing cognitive learning outcome and performance. By participating, students can gain insights into effective self-management of their learning capabilities, fostering a quality learning experience. Additionally, the study provides valuable information for students to uncover the essential foundations for maximizing their performance in Science.
2. For teachers, it suggests exploring the results of this study to gain additional insights on incorporating SOLO Taxonomy into teaching methodologies. Understanding how to integrate this taxonomy can enhance the teaching of Science courses, fostering interactive and collaborative learning that stimulates various skills and intelligence among students.
3. School administrators are recommended to leverage the study's findings to identify effective learning competencies. This information can guide schools in continuing to adapt and implement SOLO Taxonomy in teaching Science and potentially extending its application to other subjects.

References:

Atherton J S (2013) Learning and Teaching; SOLO taxonomy [On-line: UK] retrieved 19 March 2015 from http://www.learningandteaching.info/learning/solo.htm.