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Knowledge and Practices on the Application of SOLO Taxonomy in Mathematics in the Division of Batangas City

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ABSTRACT

This study assessed the levels of knowledge and practices of mathematics teachers on the application of the Structure of Observed Learning Outcomes (SOLO) taxonomy in the Division of Batangas City. It also examined whether significant differences exist in these variables when respondents are grouped according to their profiles. A descriptive research design was used, using a researcher-made questionnaire as the primary data collection tool complemented with focus group discussion to gain a deeper insight on the challenges in applying the SOLO taxonomy. The study involved 115 public junior high school mathematics teachers of SY 2024-2025 who are generally aware of the taxonomy, exceeding the minimum required sample size of 105 based on the Raosoft calculator. Data were analyzed using frequency, percentage, weighted mean, independent t-test, F-test and thematic analysis. Findings indicated that respondents demonstrated a general awareness of the SOLO taxonomy, particularly in foundational concepts. A significant relationship was found between knowledge and the grade level handled, as well as between practices and the highest educational attainment. Activities such as aligning summative assessments, sequencing activities, and linking mathematical concepts to real-world applications, shows a highly practiced activity. However, some practices are moderately practiced such as administering pre-assessments, using visual aids, and incorporating technology. Respondents reported challenges in understanding taxonomy's levels and concepts, along with limited opportunities for professional development. The results and findings of this study served as a bases in preparing a learning material with the integration of SOLO taxonomy for mathematics instruction.

Keywords: SOLO Taxonomy, Junior High School, Mathematics Education, Knowledge, Practices

1. INTRODUCTION

Education is the most powerful tool in shaping 21st century learners, preparing them with the essential needs to succeed in an increasingly complex and competitive world. It serves as a substance for innovation, critical thinking, and problem-solving skills that are predominantly crucial in mathematics and other academic disciplines. However, despite its importance, the Philippines continuously face significant challenges in mathematics education, as reflected in various worldwide assessments.

The 2018 Programme for International Student Assessment (PISA) ranked the Philippines 78th out of 79 countries in mathematics, indicating a significant gap in students' ability to apply mathematical concepts to real-world problems (OECD, 2019). Similarly, the Trends in International Mathematics and Science Study (TIMSS) 2019 placed Filipino Grade 4 students at the bottom among 58 countries, scoring an average of 297—far below the international benchmark of 500 (IEA, 2020). Moreover, the Southeast Asia Primary Learning Metrics (SEA-PLM) 2019 revealed that only 17% of Filipino students achieved the minimum proficiency level in mathematics, highlighting the urgent need for reform in how math is taught and assessed in schools (UNICEF, 2020). These underwhelming results highlight the urgent need for improved instructional strategies and assessment frameworks.

Research by Orale and Uy (2018) attributes these struggle to an overreliance on rote memorization, a lack of conceptual understanding, and insufficient exposure to problem-solving strategies. Traditional assessments predominantly emphasize procedural fluency, thereby neglecting the development of higher-order thinking skills essential for real-world application. This emphasis hinders students' ability to apply mathematical concepts in unfamiliar contexts. Addressing these gaps in mathematics instruction underscore the urgent need for a more effective framework that fosters deeper learning and comprehensive understanding.

Amidst these challenges, certain schools in the Philippines have recognized as centers of excellence in mathematics, producing students who consistently achieve top rankings in national and international competitions. Their success reflects not only strong foundational instruction but also the implementation of effective teaching strategies which fosters deeper conceptual understanding and problem-solving skills. These schools serve as models of how innovative assessment and learning approaches can bridge educational gaps and elevate student performance to globally competitive standards (Matanguihan & Chua, 2024).

A key factor contributing to their success is the alignment of their curriculum on Structure of Observed Learning Outcomes (SOLO) Taxonomy which was introduced by John Biggs and Kevin Collis in 1982. This taxonomy classifies learning into five progressive stages: Pre-structural, Uni-structural, Multi-structural, Relational, and Extended Abstract. This structured approach promotes deeper understanding by evaluating students' thinking processes rather than just their ability to recall concepts. Unlike traditional assessments that primarily focus on solving problems through memorization and routine procedures, SOLO Taxonomy ensures that students’ progress from basic knowledge to higher-order thinking, problem-solving, and analytical reasoning.

Several studies have demonstrated the effectiveness of the SOLO Taxonomy in assessing and improving students' mathematical understanding and problem-solving skills. The study of Adeniji (2022), strongly supports the relevance of SOLO Taxonomy in mathematics education, emphasizing its effectiveness as a structured assessment and instructional tool. It reveals that SOLO Taxonomy is highly effective in measuring learning outcomes across various mathematics topics, demonstrating a direct correlation between students' performance levels and their SOLO attainment. Additionally, its consistent success in assessing and informing instruction further proves that it is a reliable framework for evaluating mathematical understanding, making it a valuable tool for enhancing mathematics education.

Additionally, the study by Alawneh (2024) highlights the significant impact of SOLO Taxonomy in teaching mathematics, particularly in facilitating students’ mastery of coordinate geometry concepts. The research emphasizes the importance of a structured, progressive learning approach, where students advance through five successive levels—from basic comprehension to abstract reasoning. Moreover, the study underscores the crucial role of teacher training in the effective implementation of SOLO Taxonomy, stressing that well-equipped educators are key to maximizing its benefits in the classroom. Alawneh also advocates for further research on its applicability in other mathematical domains, such as algebra, probability, and statistics, to explore its broader potential in enhancing conceptual understanding across different topics.

In the Philippine context, the integration of SOLO taxonomy into national education reform initiatives became prominent around 2021. During this period, the National Educators Academy of the Philippines (NEAP) collaborated with the Research Center for Teacher Quality (RCTQ) to develop Professional Learning Packages (PLPs) in Mathematics, Science, and English/Reading for teachers handling grades 7 and 8, and grades 9 and 10. This four-day seminar attended by master teachers and school leaders aims to develop teaching guide materials and classroom activities that promote higher-order thinking skills through the use of SOLO-based pedagogy and assessment strategies.

DepEd CALABARZON urgently released a memorandum recognizing the potential of SOLO Taxonomy and actively promotes its use to enhance assessment practices and foster higher-order thinking skills among educators and students. Through initiatives like the Regional Training on Higher Order Thinking Skills (HOTS) Professional Learning Packages (PLPs), teachers receive strategies to improve students' conceptual understanding and critical thinking. Schools Division Offices, including SDO Batangas City (Division Memorandum No. 475, s. 2023), SDO Lucena City (SGO-2024-004) and SDO Tayabas City (Division Memorandum No. 418, s. 2023), have also issued memoranda supporting its implementation. These efforts highlight DepEd CALABARZON’s commitment to strengthening teaching, learning, and assessment through a structured, effective framework.

However, despite this initiative, its implementation remains weak. Many teachers struggle to apply SOLO Taxonomy effectively due to inadequate training, limited enrichment programs, and a lack of standardized assessment materials. While DepEd has introduced seminars on SOLO Taxonomy, their limited scope and follow-up support prevent teachers from fully integrating it into their classrooms. Research suggests that successful curriculum reforms require ongoing professional development, mentoring, and collaborative learning communities among educators (Darling-Hammond et al., 2017). Without continuous training and hands-on application, teachers may revert to traditional assessment methods that focus on procedural fluency rather than deep conceptual understanding. Strengthening professional development programs tailored to SOLO Taxonomy is essential to ensuring its effective and sustainable integration into the mathematics curriculum.

Furthermore, the implementation of SOLO Taxonomy aligns with the Department of Education’s broader initiatives for curriculum reforms, such as the Mathematics Framework for Philippine Basic Education and the Sulong Edukalidad campaign, which emphasize higher-order thinking skills, problem-solving, and conceptual understanding. The MATATAG Curriculum introduced in 2023 also aims to enhance foundational skills and improve students' critical thinking abilities, making the adoption of structured assessment frameworks like SOLO Taxonomy even more relevant. By integrating SOLO Taxonomy into mathematics instruction, educators can better align with DepEd’s goal of shifting from rote memorization to meaningful learning experiences that prepare students for real-world applications. Strengthening its implementation will not only improve assessment practices but also contribute to national education reforms aimed at producing globally competitive learners.

While these national initiatives and the integration of SOLO Taxonomy present promising theoretical benefits, there remains a significant gap in empirical research. Existing research has highlighted the effectiveness of SOLO Taxonomy in measuring learning outcomes and promoting higher-order thinking. However, empirical studies on how teachers integrate SOLO Taxonomy into their assessment practices and the challenges they face in real classroom settings are scarce. Understanding these practical barriers is crucial for ensuring the successful implementation of SOLO Taxonomy, thereby enabling educators to harness its full potential to enhance student learning and performance.

Despite the growing recognition of SOLO Taxonomy in the Philippine education system, its practical application in everyday teaching remains limited. There is a pressing need to examine how educators perceive, understand, and implement this framework, as well as the obstacles preventing its full integration into the classroom. Addressing these issues will provide valuable insights into strengthening assessment practices and improving student learning outcomes.

With this thought in mind, the researcher aims to evaluate teachers' knowledge and practices in applying SOLO Taxonomy within the mathematics curriculum of public schools in the Division of Batangas City. Moreover, this study seeks to identify the challenges educators encounter in its application. As a Grade 9 mathematics teacher, the researcher is also committed to develop a learning material that effectively integrates SOLO Taxonomy, thereby enhancing teaching strategies and improving student learning outcomes.

2. OBJECTIVES

This study sought results and findings of the following objectives.

1. Determine the profile of the respondents in terms of:
   1.1 grade level handled
   1.2 highest educational attainment
   1.3 teaching experience
   1.4 number of seminars attended
2. Assess the level of knowledge and practices of the respondents in applying SOLO taxonomy
3. Find the difference in level of knowledge and practices of SOLO when the respondents are grouped according to their profile
4. Identify the challenges in using the SOLO taxonomy
5. Prepare a SOLO-based learning material in teaching mathematics

3. MATERIALS AND METHODS

This study used descriptive research design using research-made questionnaire to assess the knowledge and practices of junior high school mathematics teachers from various public schools within the Division of Batangas City. Out of 143 mathematics teachers, a sample size of 105 was recommended using Raosoft calculator. However, this study included 115 junior high school mathematics teachers of SY 2024-2025 who are generally aware of the taxonomy.

To gather the necessary information, the researcher utilized a researcher-made questionnaire as the primary source of quantitative data. The questionnaire has four parts: (1) the respondents' profile, including grade level handled, highest educational attainment, years of teaching experience, and the number of seminars attended about SOLO taxonomy, (2) a screener question assessing the respondents' awareness of the taxonomy; those who indicated "Not Aware" were excluded from the study, (3) a knowledge test about the concepts, level and purpose of the taxonomy and (4) the evaluation of teacher's level of knowledge through Likert-scale. Both onsite and online questionnaire was distributed through school principals across public schools in the Division of Batangas City.

On the other hand, the researcher invited teacher representatives to participate in an online focus group discussion conducted via Google Meet. This method helps the researcher in gaining deeper insights on the difference challenges faced by the respondents in applying SOLO Taxonomy in their mathematics instructions.

Several statistical measures and tests were used to systematically analyze and interpret the gathered data. Frequency, percentage, F-test, independent t-test, and weighted mean were employed to describe the respondents' profiles and determine differences in their knowledge and practices regarding SOLO taxonomy. Additionally, thematic analysis was conducted to categorize and interpret qualitative responses, identifying common challenges in its application.

3. RESULTS AND DISCUSSION

This part discusses the key findings and results obtained in the study.

3.1 Profile of the Respondents

This section provides insights about the background and qualifications of the respondents, encompassing their grade level handled, highest educational attainment, teaching experience and number of seminars attended about SOLO taxonomy.

Table 1. Distribution of Respondents' Grade Level Handled

	Frequency	Percentage
Grade 7	22	19.1
Grade 8	29	25.2
Grade 9	32	27.8
Grade 10	32	27.8
Total	115	100

From the table above, it can be noticed that respondents are almost equally distributed in handling Grade 7 to Grade 10. This aligns to the initial data from SDO Batangas City (when grouped according to schools), which suggests that most schools especially those in remote areas employ four mathematics teachers, one assigned per grade level. With this, the data may be generalized across all schools within the division of Batangas City.

Table 2. Distribution of Respondents' Highest Educational Attainment

	Frequency	Percentage
Bachelor's Degree	58	50.4
Master's Degree	57	49.6
Total	115	100

The respondents are almost evenly split between those who completed bachelor's degree and those who have earned a master's degree based on Table 2. This implies that a bachelor's degree is a basic qualification for teachers, especially for those who are just starting their teaching careers and a value of earning master's degree which many experienced teachers pursue as part of their professional growth.

Table 3 reveals that most of the respondents have more than 6 years in teaching with the highest percentage of 67.80. On the other hand, 32.20 of the respondents have less than 6 years in the field. A smaller portion of the respondents are relatively newer to the profession reflecting a mix of both seasoned and less experience teachers. This implies that combination of experience levels creates a balanced teaching workforce. As seasoned teachers can guide new ones, while newer teachers can share fresh ideas and energy.

Table 3. Distribution of Respondents' Teaching Experience

	Frequency	Percentage
6 years and below	37	32.2
More than 6 years	78	67.8
Total	115	100

Looking at Table 4 below, it shows that most of the respondents have limited exposure to seminars on SOLO taxonomy while only a small portion having attended more than one. Since, DepEd-NEAP starts collaborating with RCTQ in 2021 there is a limited training/seminar raised during this period. This also implies that providing follow-up sessions and mentoring programs focusing on SOLO taxonomy would significantly enhance their understanding and support the effective application of this knowledge.

Table 4. Distribution of Respondents' Number of Seminars about SOLO

	Frequency	Percentage
One Seminar	102	88.7
Two Seminars	13	11.3
Total	115	100

3.2 Level of Knowledge and Practices of the Respondents in the use of SOLO Taxonomy

This section provides insight on the level of knowledge and practices of the respondents in the use of SOLO Taxonomy.

Table 5. Teachers' Level of Knowledge on SOLO

	Frequency	Percentage
Moderately	9	7.8
Knowledgeable	47	40.9
Highly	59	51.3
Total	115	100

The results of the SOLO Taxonomy knowledge test, as presented in Table 5, reveal a varied range of understanding among the respondents. It is evident that the majority possess a strong grasp of the fundamental concepts of SOLO Taxonomy. Most respondents correctly identified the meaning of SOLO as the Structure of Observed Learning Outcomes, recognized its primary proponent and developer, recalled the year it was introduced, and acknowledged the key collaborators involved in refining and extending the framework. These findings indicate a comprehensive awareness of the foundational aspects of SOLO Taxonomy among participating mathematics teachers.

In contrast, the results show that respondents are only moderately knowledgeable about the purpose and practical applications of SOLO Taxonomy. While many recognize its alignment with assessment processes and its role in improving the evaluation of student learning, there remains limited understanding of its specific objectives — such as determining appropriate assessment types and defining the teacher's role in its classroom implementation. This reflects a need for further professional development focusing on how SOLO Taxonomy can effectively support both formative and summative assessments to foster meaningful learning outcomes.

Conversely, a significant degree of uncertainty was observed regarding the hierarchical structure of the SOLO Taxonomy. Many respondents appeared less confident in identifying the total number of levels, their correct sequence, and the characteristics associated with each stage — particularly in areas linked to the development of critical thinking, independent learning, knowledge application, and recognition of insufficient understanding.

A small portion of respondents also demonstrated only moderate overall knowledge, highlighting a group that would benefit from additional targeted training and capacity-building initiatives. Overall, the knowledge level of the respondents reflects promising potential for further growth, which can be attributed in part to the continuous efforts of DepEd CALABARZON in conducting seminars and workshops that provide educators with foundational exposure to SOLO Taxonomy. These learning sessions, complemented by school-based re-echo seminars, have emphasized the importance of revisiting core concepts and clarifying the hierarchical structure — reinforcing the need for sustained and expanded training opportunities to deepen teachers' competence in applying the taxonomy within their instructional practices.

Table 6 shows that there is a relatively strong adoption of SOLO Taxonomy practices among the majority of the respondents. As more than half of the group are practicing or actively implementing the SOLO Taxonomy's principle regularly in their instruction. On the other hand, a very small portion of the group who only moderately practiced or doesn't regularly use in their instructional approaches indicating a potential area for professional development and training.

Table 6. Teachers' Level of Practices on SOLO

	Frequency	Percentage
Moderately	9	7.8
Practiced	52	45.2
Highly	54	47.0
Total	115	100

Activities such as aligning summative assessments (quizzes and projects) with the different levels, planning the sequence of activities from basic to advanced comprehension, and connecting mathematical concepts to real-world scenarios revealed a highly practiced activity. These practices indicate a strong emphasis on structuring lessons that allow students to progressively build understanding, engaging in real-life applications and assessments that reflect different cognitive levels as defined by SOLO Taxonomy.

Table 7. Respondents' Assessment in their Practices on SOLO Taxonomy

In my mathematics class I use SOLO taxonomy to ……		WM	SD	Interpretation
1.	align summative assessments, such as quizzes or projects, with the levels addressed in the lesson.	3.57	.578	Highly Practiced
2.	plan the sequence of activities in the lesson to progress from basic comprehension to more advanced applications.	3.52	.597	Highly Practiced
3.	connect mathematical concepts to real-world scenarios, challenging students to apply their understanding in contextually relevant situations, thus fostering deeper comprehension and application skills.	3.50	.680	Highly Practiced
4.	administer pre-assessment tasks that are aligned to evaluate students' current comprehension of the topic.	3.47	.653	Moderately Practiced
5.	implement the think-pair-share strategy, promoting student engagement and deepening understanding by allowing them to discuss concepts with peers and articulate their thinking at different levels.	3.44	.665	Moderately Practiced
6.	align the lesson objectives with its different levels, specifying the depth of understanding students should achieve by the end of the lesson.	3.43	.578	Moderately Practiced
7.	incorporate questioning strategies that prompt students to think critically and engage with mathematical concepts at different levels, fostering deeper understanding.	3.43	.608	Moderately Practiced
8.	conclude the lesson with a summary or reflection activity.	3.40	.698	Moderately Practiced
9.	utilize visual aids, diagrams, and models, supporting students' comprehension and facilitating their progression through different levels of understanding.	3.39	.710	Moderately Practiced
10.	include opportunities for peer collaboration and discussion, enabling students to explain concepts to each other and engage in dialogue that promotes deeper understanding across various levels.	3.39	.658	Moderately Practiced
11.	encourage peer teaching opportunities where students take turns explaining concepts to each other.	3.38	.670	Moderately Practiced
12.	encourage students to engage in metacognitive reflection by prompting them to evaluate their understanding and identify areas for improvement based on SOLO criteria.	3.32	.720	Moderately Practiced
13.	design learning activities that cater to students at various levels of understanding, offering differentiated tasks to meet diverse learning needs.	3.27	.667	Moderately Practiced

14.	integrate formative assessment techniques such as exit tickets, concept maps, or peer feedback, aligning them with students' progression levels to monitor their understanding and provide timely feedback.	3.23	.689	Moderately Practiced
15.	incorporate technology tools and digital resources, aligning them to provide interactive and adaptive learning experiences that offer personalized support and enrichment opportunities.	3.23	.798	Moderately Practiced
16.	incorporate modelling activities, where students create mathematical models to represent real-world situations.	3.18	.833	Moderately Practiced
17.	provide tiered assignments that offer varying levels of challenge, aligned with students' current understanding.	3.17	.775	Moderately Practiced
18.	utilize graphic organizers like concept maps or Frayer models which help students to organize and connect mathematical ideas across different levels of understanding	3.04	.821	Moderately Practiced
19.	integrate hands-on activities and manipulatives to assist students in constructing a concrete understanding of mathematical concepts before progressing to more abstract levels.	3.04	.718	Moderately Practiced
20.	design project-based learning tasks that require students to investigate, problem-solve, and present findings.	3.00	.795	Moderately Practiced
	COMPOSITE MEAN	**3.32**	**.528**	**Moderately Practiced**

On the other hand, most of the activities fall into the moderately practiced category, indicating that while SOLO Taxonomy is used consistently, there is a room for improvement in how it is integrated into certain teaching strategies. Activities such as administering pre-assessments, using visual aids, and incorporating technology tools are applied at a moderate level. These practices contribute to fostering a deeper understanding of mathematical concepts but may not be implemented as frequently or comprehensively as the more highly practiced activities.

The overall moderately practiced score, with a standard deviation of 0.528, implies that while SOLO Taxonomy is largely embedded in the respondents' teaching practices, continuous professional development and focused follow-up activities could help enhance the use of more advanced SOLO-based strategies, ensuring its broader and deeper application in the classroom.

3.3 Difference in Level of Knowledge and Practices of SOLO Taxonomy when the Respondents are grouped according to Profile

This section discusses the differences in the level of knowledge and practices of SOLO Taxonomy among the respondents based on their profile. The analysis explores how factors such as grade level handled, educational attainment, teaching experience, and number of seminars attended about SOLO Taxonomy may influence the respondents' understanding and application of SOLO Taxonomy in their mathematics teaching practices.

Table 8 revealed that there is a significant difference in the respondents' level of knowledge on SOLO taxonomy when grouped according to the grade level they handled with the F-value of 2.880 and p-value of 0.039. With this, it suggests that the teachers' grade level handled affects their knowledge in SOLO taxonomy due to second-hand information from peers. Such informal sources can lead to a limited or fragmented understanding of the taxonomy.

Table 8. Difference in the Respondents' Level of Knowledge and Practices on SOLO Taxonomy when grouped according to Grade Level Handled

	Mean	SD	F-value	p-value	Decision on H0	Interpretation
Knowledge						
Grade 7	12.91	1.019	2.880	.039	Reject	Significant
Grade 8	12.10	1.205				
Grade 9	12.81	1.203				
Grade 10	12.31	1.306				
Practices						
Grade 7	3.18	.518	1.234	.301	Failed to Reject	Not Significant
Grade 8	3.37	.564				
Grade 9	3.27	.508				
Grade 10	3.43	.516				

On the other hand, the table revealed no significant difference across respondents' practices and grade level handled with the computed F-value of 1.234 and a p-value of 0.30. This implies that regardless of the grade level they handled, teachers apply similar instructional strategies and methodologies in their mathematics classes. The consistency in practices may be attributed to standardized teaching methods, curriculum guidelines, or professional development programs that promotes even application of teaching strategies.

In general, as grade level handled influences teachers' knowledge of SOLO taxonomy, it doesn't necessarily impact how they apply it in their teaching practices. It emphasizes the need for targeted training programs that ensure all teachers, regardless of the grade level they handled, must have a strong foundation in both understanding and implementing SOLO taxonomy in their mathematics classes. Strengthening professional development initiatives can help bridge knowledge gaps and enhance the effective use of SOLO taxonomy in mathematics education.

Table 9. Difference in the Respondents' Level of Knowledge and Practices on SOLO Taxonomy when grouped according to Highest Educational Attainment

	Mean	SD	t-value	p-value	Decision on H0	Interpretation
Knowledge						
Bachelor's Degree	12.55	1.245	.339	.736	Failed to Reject	Not Significant

Master's Degree	12.47	1.226				
Practices						
Bachelor's Degree	3.47	.448	3.328	.002	Reject	Significant
Master's Degree	3.17	.562				

Table 11 show that there is no significant difference in knowledge between highest educational attainment with the computed t-value of 0.339 and a p-value of 0.736. Therefore, the null hypothesis was not rejected, suggesting that highest educational attainment does not significantly affect knowledge on the use of SOLO taxonomy. Factors such as professional development, teaching experience, or exposure to SOLO taxonomy may have a greater influence on knowledge acquisition.

On the other hand, Table 11 revealed a significant difference on practices across highest educational attainment with the computed t-value of 3.328 and a p-value of 0.002. Thus, the null hypothesis was rejected, suggesting that the highest educational attainment has a significant effect on practices. Teachers holding a Bachelor's degree demonstrated more frequent or distinct practices compared to those holding a Master's degree. This indicates that teachers with Bachelor's degree are more inclined to apply structured teaching strategies, including SOLO taxonomy, in their mathematics classes. Conversely, teachers with a Master's degree tend to incorporate a broader range of methodologies, leading to more diverse classroom practices.

In general, it is evident that educational attainment alone does not guarantee an expertise in understanding the SOLO taxonomy. Thus, continuous trainings and hands-on experiences is an essential remedy in strengthening both knowledge and application of SOLO taxonomy. Still, providing professional development programs can ensure effective application of SOLO taxonomy in mathematics instruction.

The result in Table 9 indicates that there is no significant difference in the respondents' level of knowledge on SOLO taxonomy when grouped according to their years in service. Teachers with different lengths of experience demonstrates a relatively similar knowledge levels, as shown by the non-significant p-value of 0.104. It indicates that years in service alone do not necessarily contribute to a deeper understanding of SOLO taxonomy, and factors such as professional development, training, or access to resources may play a more crucial role in enhancing teachers' knowledge.

Table 9. Difference in the Respondents' Level of Knowledge and Practices on SOLO Taxonomy when grouped according to Years in Service

	Mean	SD	t-value	p-value	Decision on H0	Interpretation
Knowledge						
6 years and below	12.24	1.517	1.438	.156	Failed to Reject	Not Significant
More than 6 years	12.64	1.057				
Practices						

6 years and below	3.36	.529	0.551	.292	Failed to Reject	Not Significant
More than 6 years	3.30	.530				

The result in Table 9 indicates that there is no significant difference in the respondents' level of knowledge on SOLO taxonomy when grouped according to their years in service. Teachers with different lengths of experience demonstrates a relatively similar knowledge levels, as shown by the non-significant p-value of 0.104. It indicates that years in service alone do not necessarily contribute to a deeper understanding of SOLO taxonomy, and factors such as professional development, training, or access to resources may play a more crucial role in enhancing teachers’ knowledge.

Similarly, when practices are grouped according to their years in service, no significant difference was found, as shown by a non-significant p-value of 0.161. Despite the respondents’ differences in terms of their years in service, teachers tend to apply comparable instructional strategies, indicating that teaching practices may be influenced more by standardized guidelines, institutional policies, or training programs rather than by the length of their service. It was highlighted that effective teaching practices are shaped by continuous learning opportunities and pedagogical training rather than experience alone.

In general, it is imperative that neither knowledge nor practices on SOLO taxonomy are significantly affected by the number of years a teacher has been in service. This emphasizes the importance of continuous professional development and structured training programs to ensure that all teachers, regardless of their experiences, acquire a strong foundation in SOLO taxonomy and apply it effectively in their teaching

Table 10. Difference in the Respondents’ Level of Knowledge and Practices on SOLO Taxonomy when grouped according to Number of Seminars attended about SOLO Taxonomy

	Mean	SD	t-value	p-value	Decision on H0	Interpretation
Knowledge						
1 Seminar	12.54	1.19	.637	.525	Failed to Reject	Not Significant
2 Seminars	12.31	1.55				
Practices						
1 Seminar	3.31	.536	-.596	.552	Failed to Reject	Not Significant
2 Seminars	3.40	.480				

Table 10 indicates that there is no significant difference in the respondents' level of knowledge on SOLO taxonomy when grouped according to the number of seminars they attended, as shown by the non-significant p-value of 0.525. Teachers who attended only one seminar and those who attended two seminars demonstrated similar levels of knowledge, as reflected in their mean scores of 12.54 and 12.31, respectively. This suggests that joining numerous seminars does not necessarily lead to a significantly higher understanding of SOLO taxonomy. This highlights that while seminars provide exposure to educational concepts, their impact on knowledge retention and application may depend on the depth and quality of training rather than just the frequency of attendance.

Similarly, no significant difference was found in teachers' practices on SOLO taxonomy across number of seminars attended, as shown by the non-significant p-value of 0.552. Teachers who attended either one or two seminars showed similar levels of practice, suggesting that simply attending more seminars does not automatically translate to improved application of SOLO taxonomy in the classroom. It is suggested that professional development is most effective when hands-on application, mentorship, and continuous support is included, rather than relying solely on seminar-based learning.

In general, it is suggested that the number of seminars attended does not significantly influence teachers' knowledge or practices related to SOLO taxonomy. This highlights the necessity for more comprehensive and immersive training programs that go beyond seminars, incorporating experiential learning, collaborative discussions, and follow-up support to ensure the effective integration of SOLO taxonomy in teaching practices.

3.4 Challenges encountered by the Teachers in Applying SOLO Taxonomy

This study also explores the different challenges in using the SOLO taxonomy in mathematics teaching. Two major concerns were identified such as understanding SOLO taxonomy and professional development. These challenges underscore the complexity involved in effectively implementing the taxonomy into mathematics instruction and highlighted the need for innovative solutions and ongoing support for educators.

A focus group discussion was conducted to deeply know the challenges encountered by selected junior high school mathematics teachers in mathematics instruction applying SOLO taxonomy. From here, corresponding themes and subthemes was encapsulated. The data presented in the table offers insights into the challenges encountered by the respondents when applying SOLO taxonomy into mathematics instruction. Through the experiences shared by the respondents, the researcher gains a deeper insights and alternative perspective among the respondents.

Table 11. Challenges Experienced/Encountered in Applying SOLO Taxonomy in Mathematics Teaching

Themes	Subthemes	Exemplar Texts
Understanding SOLO Taxonomy	Confusion in distinguishing levels and concepts	Unclear distinction of SOLO taxonomy levels. [P1] Unsure of constructing learning tasks from surface to deeper understanding as outlined by SOLO. [P4]
	Designing Lessons and Assessments	Time constraints is also a challenge, since each period requires 45 minutes and it makes hard to craft

		a well-versed lesson which is aligned to SOLO levels. [P2] The responses of each student are also a problem especially in feedbacking, time-consuming. [P6] DepEd had a memo on implementation of SOLO taxonomy but materials to succeed is not thoroughly given. [P6]
Professional Development	Limited Access to training	Most of the attendees in our school are department heads, thus they are the only persons who are well-versed in the trainings attended about SOLO taxonomy. [P3] No formal training for regular teachers, though we acquire minimal idea through re-echo seminar. [P1]
	Lack of Follow Up and Support Sessions	Attended once, but there is no more follow up sessions. [P2]

Teachers commonly identified their understanding of the SOLO taxonomy as the greatest challenge in its application. Many respondents admitted to difficulties in grasping its structure, leading to challenges in distinguishing between its hierarchical levels and conceptual categories. This confusion often resulted in misinterpretation and inconsistent use of the framework in practice.

Respondents expressed uncertainty in differentiating the taxonomy's levels, making it difficult to properly classify learning outcomes. One participant shared:

"…In my experience, one of the primary challenges I encountered is assessing the learning outcomes using SOLO taxonomy levels whether my students fall on unistructural, multi-structural, relational or extended abstract. It is remained unclear." [P1]

Similarly, another teacher highlighted the difficulty of constructing learning tasks that progressively move from surface to deeper understanding as outlined by SOLO:

"…Since most of the teachers are not predominantly attending seminars about SOLO, aligning objectives is a real challenge. We are unsure on how to construct learning tasks from surface to deeper understanding as outlined in SOLO". [P4]

Participant [P2] further emphasized the need for training opportunities to strengthen teachers' understanding of the taxonomy.

Aside from conceptual challenges, respondents encountered practical difficulties in applying the taxonomy in lesson planning and assessment. Teachers noted that creating SOLO-based lesson designs was time-consuming, particularly within the 45-minute class period. Participant [P2] explained:

"…In my math class, I only have 45 minutes per period, and designing a SOLO-based lesson design that would fit on that time would not be possible. In a certain topic, I need to check if all of my students can step up to the next level of SOLO, and if not, I need to repeat so that no one will be left behind. Teachers also need to follow the time frame of each lesson as required." [P2]

Similarly, providing feedback tailored to individual students' SOLO levels was identified as a demanding task, especially with large class sizes:

"…It is really a time-consuming task, especially in feedbacking. As a teacher, we are handling not only one section, usually 4-5 sections, with more or less 40 students each. When it comes to checking (of approximately 200 individual students), it will really cost a lot of your time." [P6]

Additionally, respondents pointed out the lack of instructional materials to support SOLO implementation, despite a DepEd memorandum advocating its use:

"…DepEd recognizes the effectiveness of this taxonomy, that is why they had a memo on implementation of it, but we are left hanging, though there are seminars and trainings attended, but this is not sufficient to effectively implement, we are in need of materials such as guidelines and the like". [P6]

Another key challenge identified was the insufficient professional development opportunities related to SOLO taxonomy. Teachers stressed the need for formal training, continuous workshops, and comprehensive learning sessions to build their confidence and competencies in applying the framework effectively.

Respondents revealed that most SOLO-related seminars were only attended by department heads, leaving regular teachers with limited exposure. As one participant shared:

"…Most of the attendees in our school are department heads, thus they are the only persons who are well-versed in the trainings attended about SOLO taxonomy". [P3]

Another participant added:

"…I am just a regular teacher, I just have minimal idea of this taxonomy through re-echo seminar by the teachers who really attends the seminar/workshop. In short, I don't have any formal training." [P1]

Participant [P5] further noted that the re-echoed training sessions lacked depth and left teachers feeling unprepared.

Teachers also observed the absence of follow-up sessions and sustained support after initial training. As one participant noted:

"…I used to attend once, but there is no more follow up sessions. Actually, we are really waiting since we are already hooked up with the first session, so what more if we acquire another?". [P2]

This lack of continuous professional development limits opportunities for teachers to deepen their understanding and refine their practices in implementing the SOLO taxonomy.

Overall, the findings suggest that successful implementation of the SOLO taxonomy requires not only clear conceptual understanding and lesson planning strategies but also sufficient training, accessible instructional materials, and sustained support systems. Addressing these challenges through targeted professional development programs, provision of curriculum resources, and collaborative learning opportunities can enhance teachers' confidence and effectiveness in applying the SOLO taxonomy to support meaningful student learning.

3.5 Proposed SOLO-based Learning Material

This SOLO-based learning material illustrates the progression from surface learning to deeper understanding through sample lessons for Grades 7 to 10. The sample lesson plans cater to the full range of SOLO levels—from pre-structural to extended abstract. It will guide teachers in designing instructional materials that effectively apply the SOLO taxonomy using the 4A format in lesson planning to ensure structured and meaningful learning experiences. Additionally, a self-assessment rubric for students will be provided which will be completed immediately after the lesson. This promotes the development of their skills, allows for progress tracking, and serves as a basis for the teacher's assessment.

4. Conclusions

Based on the findings, the following conclusions could be drawn:

1. The respondents were almost evenly distributed across grade levels, with most holding either a bachelor's or a master's degree. A majority had over six years of teaching experience but limited seminar exposure on the SOLO taxonomy.
2. Most teachers demonstrated strong to highly knowledgeable understanding of the SOLO taxonomy. However, actual classroom practices were generally moderate, indicating a gap between knowledge and consistent application.
3. Significant differences in knowledge appeared when respondents were grouped by grade level handled, while differences in practices were observed based on highest educational attainment.
4. Teachers faced two major challenges: difficulty in fully understanding the taxonomy's levels and applying them in lesson planning and assessment, and limited access to continuous training and follow-up support.
5. To address these gaps, a SOLO-based assessment tool was developed, featuring sample lesson plans for Grades 7 to 10 aligned with SOLO levels and a student self-assessment rubric to enhance learning progress and teacher evaluation.

5. Recommendations

Based on the findings and conclusions, the following are the recommendation of the researcher:

1. Sustained and targeted professional development programs may be provided for mathematics educators to deepen their understanding of the SOLO taxonomy and enhance its integration into instructional and assessment practices.
2. Educators may be encouraged to remain open to change and embrace innovative pedagogical approaches. The effective use of frameworks like the SOLO taxonomy requires a willingness to reflect, adapt, and respond to students' evolving learning needs.
3. Future studies may explore the application and impact of the SOLO taxonomy in other subject areas to determine its broader relevance and effectiveness in diverse educational settings.
4. The Department of Education may consider providing support for the implementation and dissemination of the SOLO-based assessment tool developed in this study. Such support can help promote its effective use in mathematics instruction and encourage its integration into teaching practices to enhance student learning outcomes.

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