IJORER : International Journal of Recent Educational Research
Homepage : https://journal.ia-education.com/index.php/ijorer
Email : ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 5, No. 3, May 2024
Page 523-536

The Effectiveness of Using the SOLO Taxonomy in Acquiring Students the Concepts of Coordinate Geometry

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DOI: https://doi.org/10.46245/ijorer.v5i3.592

Sections Info

Article history:
Submitted: March 16, 2024
Final Revised: April 6, 2024
Accepted: April 16, 2024
Published: May 13, 2024

Keywords:
Coordinate Geometry;
Mathematical Concepts;
Mathematics Education;
SOLO Taxonomy.

ABSTRACT

Objective: The study aimed to investigate the effect of using the SOLO taxonomy levels on Prince Faisal Technical College students' acquisition of coordinate geometry concepts. To achieve the study's objective, **Method:** The researcher developed a test of acquisition of coordinate geometry concepts. The study used the semi-experimental approach with a pre-post design, and it was applied to (51) students from the college, who were divided into two groups: one experimental (25) student studied using the SOLO taxonomy levels, and the other controlled (26) students studied in the usual way. **Results** showed a positive effect of using the SOLO taxonomy as a strategy for teaching mathematics, especially in students' acquisition of concepts of coordinate geometry. The study recommended using the SOLO Taxonomy levels on students' acquisition of mathematical concepts in other fields such as algebra, statistics, etc. **Novelty:** This research presents novelty through the use of Solo taxonomy levels of classification in teaching mathematics, designing a teaching strategy to enable students to acquire concepts of coordinate geometry so that it is easy for teachers to implement this strategy in teaching mathematics.

INTRODUCTION

Modern mathematics is characterized by the fact that they are tight structures that are closely connected, eventually forming an integrated structure. The building blocks of this construction are mathematical concepts, as principles, generalizations, and mathematical skills rely heavily on concepts. One of the primary and essential components of mathematics is geometry, which is characterized by a logical sequence and abstraction in concepts and principles due to the multiplicity of types of mathematical knowledge in it (concepts, skills, facts, generalizations, laws, and postulates), and concepts are considered the main component in geometry (Bounou et al., 2023). Geometry concepts represent the basic rules in geometry construction, as it is one of the most important goals of the geometry learning process because understanding and applying geometry concepts correctly necessarily leads to the ability to learn various skills in geometry (Parissi et al., 2023).

Teachers seek to acquire their students' mathematical concepts using multiple methods and models, as these models enable students to build their mathematical concepts. One of these models is known as the SOLO taxonomy levels. By adopting constructivist theory, Biggs & Collis (1982) proposed a single Taxonomy to describe the learning hierarchy, in that each partial structure (level) becomes a foundation on which learning is further enhanced and expanded. The SOLO taxonomy levels include five levels of development, and these levels are arranged in terms of the

Different characteristics represent student learning, from the concrete to the abstract and the surface to conceptual understanding (Adeniji et al., 2022; Egodawatte, 2023; Feldman-Maggor et al., 2022; Jaiswal & Al-Hattami, 2020; Koyunlu et al., 2022).

SOLO taxonomy levels are considered independent content; therefore, it can be used as a general measure of understanding across disciplines, a developmental scheme to classify learning outcomes in terms of complexity, thus enabling teachers to evaluate student work in terms of its quality rather than in terms of the number of correct responses in a given task or activity (Chan et al., 2022). Teachers can use SOLO taxonomy levels to determine intended learning outcomes, the instructional methods that support them, and forms of assessment that assess the extent to which outcomes have been achieved (Al et al., 2023; Banda et al., 2023; Egodawatte, 2023; Karanja & Malone, 2021; Muhayimana et al., 2022).

Biggs (2003) suggested that SOLO taxonomy levels are applicable and measure learning outcomes achieved in different cognitive domains and subjects, between different levels of students, and in different types of tasks. Therefore, SOLO Taxonomy levels provide a qualitative way to classify cognitive processes, which have been applied to many subjects, such as mathematics. SOLO taxonomy levels refer to observed learning outcomes, where the learning outcomes reached by students are examined to investigate the factors behind the difference between students in the performance of specific tasks. It consists of qualitatively different levels, hierarchically from the imperfect level at the bottom of the pyramid in which responses are non-constructive and disconnected to higher experiences involving high levels of abstraction (Ladias et al., 2022); this taxonomy stands out because it runs parallel to the stages of Piaget's cognitive development.

SOLO taxonomy levels provide a hierarchical model for qualitative analysis of students' responses to specific tasks. It is widely seen as an effective tool in interpreting and evaluating students' mathematical thinking skills about certain concepts from primary to university education (Ladies et al., 2021), and applying SOLO taxonomy levels in education helps students identify and prepare the best answer. This foundation provides teachers with a systematic and hierarchical way to help students develop their thinking skills while answering each question. It also helps teachers and students understand and evaluate learning experiences and outcomes regarding cognitive complexity. Biggs (2003) provided an illustration showing the levels of the SOLO taxonomy, which starts at the pre-structural level and ends at the abstraction level.

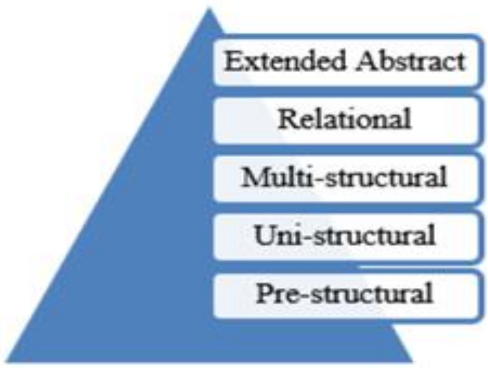


Figure 1. Levels of the SOLO taxonomy.

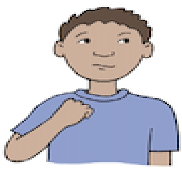
Mulbar et al. (2018) explained the five SOLO taxonomy levels:

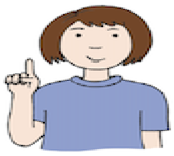
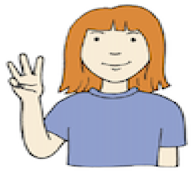
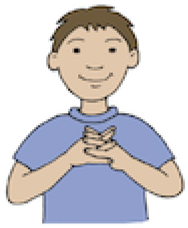
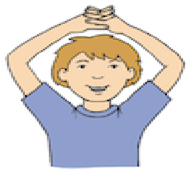
1. Pre-structural Level
   Students use incorrect information in the solution, so their conclusion needs to be corrected or irrelevant; students have little irrelevant information, so it does not constitute a concept, and students cannot work on a particular task correctly.
2. Uni-structural Level
   Students use at least one piece of information, use a single solution concept or process, and use a process based on selected information to solve the problem correctly, but irrelevant conclusions are drawn.
3. Multi-structural Level
   Students use multiple information sources but need help finding a relationship between them, so they cannot draw relevant conclusions. Students can make some correlations between many information sources, but these relationships must be more appropriate, making the conclusions irrelevant.
4. Relational Level
   Students use multiple pieces of information for the concept, provide interim results, and then link the information to draw relevant conclusions. Students connect the concept to obtain all relevant information and conclusions.
5. Extended abstract level
   Students use multiple sources of information, apply the concept, and provide interim results. Then, they link the information to draw relevant conclusions, generalize the results, think conceptually, and generalize about others' knowledge and experience.

Hamdan & Majdouba (2018) clarified that it is not required for the student to pass all levels so that he can learn within one or more levels, and that depends on several factors and variables, including the nature of the activity or subject that the student wants to learn, as Ying and Leon (2013) used in their study of the single-constructive level, the multi-constructive level, and the relational level only in students' learning to solve the linear problem.

Caniglia & Meadows (2018) pointed out the essential features of the SOLO Taxonomy levels, namely thinking states and levels of response, where SOLO Taxonomy levels of thinking (concrete and formal symbolic) are similar to Brunner's learning styles, where thinking states develop in both at the learner. The second key characteristic is the level of responsiveness, or the individual's ability to respond to the increasing complexity of the task, because the SOLO Taxonomy levels describe levels of complex comprehension progressively through five general stages. Hook (2015) illustrated the five SOLO taxonomy levels, using hand signals to express them, and the educational actions that fall under each level, likely in Table 1.

Table 1. An illustration of the five SOLO taxonomy levels.

Action	Sign	Solo Taxonomy Levels
_____		Pre-structural

Action	Sign	Solo Taxonomy Levels
Define Identify Label Do simple procedure		Uni-structural
Describe List outline		Multi-structural
Sequence Classify Explain Compare Analyze Apply		Relational
Generalize Create Reflect Predict		Extended abstract

The previous literature referred to some studies that dealt with SOLO taxonomy levels, such as Mehmet & Yilmaz's (2021) study that aimed to examine the geometric thinking levels of middle school mathematics teachers according to the SOLO taxonomy. The study was conducted using a case study. The study sample consisted of 80 teachers who taught at a public university in Turkey in the Department of Teaching Mathematics in preparatory schools. They were selected using a cluster random method, where the teachers who studied the courses "Basics of Mathematics 2" and "Special Teaching Methods 2" were selected. Semi-structured interviews were conducted with 15 teachers, and the results showed low geometry thinking levels.

Elazzab and Kacar's (2020) study examined the skills of Libyan and Turkish students in quadratic equation problems based on the SOLO taxonomy levels. The participants were 27 high school students in Kastamonu, Turkey, and 27 in Tripoli, Libya. The data were obtained using a reasoning test consisting of three problems. The test was applied to students in the spring semester of the academic year 2017-2018. In general, the results showed that Turkish students had multiple levels of 48.15% and relational levels of 10.37%, which is a good percentage, and they were better than Libyan students with multiple levels of 21.50% and relational levels of 9.00. %. This indicates that most Turkish students participating in the study may succeed in transitioning between levels of advanced thinking.

Caniglia and Meadows (2018) aimed to analyze the answers of pre-service secondary mathematics teachers in solving conceptually rich problems using SOLO taxonomy levels. A panel of three mathematics teachers analyzed 15 answers from 15 teachers. The results showed that most of the answers provided were procedural, and there needs to be more pre-service secondary mathematics teachers in conceptual understanding and depth of knowledge.

The Apawu et al. studies (2018) examined the work processes that Ghanaian secondary school students use when dealing with algebra problems. The study used a survey design, with a total sample of 304 secondary school students from three secondary schools in the central region of Ghana. Data was collected through the Super Item Test based on the SOLO taxonomy Levels test. Qualitative data were coded and analyzed into subjects. The results showed that most students surveyed needed help finding a link between the learned algebraic concepts and the non-routine problems.

Through his work as a mathematics teacher at Prince Faisal Technical College, the researcher noticed an apparent weakness in students' understanding of mathematical concepts in general and geometry concepts in particular. This weakness is reflected in their achievement in the mathematics course approved by Al-Balqa Applied University within the study plan for engineering majors. It also affects the results of the comprehensive exam for intermediate college students in Jordan, and by examining the previous literature, the researcher noticed a weakness in geometry among students in general.

This study will attempt to answer the following central question: What is the effectiveness of using the SOLO taxonomy levels in teaching Prince Faisal Technical College students the concepts of coordinate geometry? The study presents the effectiveness of the SOLO taxonomy levels in teaching the students of Prince Faisal Technical College the concepts of coordinate geometry, and this Taxonomy may be helpful in the student's possession of the concepts of coordinate geometry. In the light of its results, the study helps to overcome the weaknesses and deficiencies suffered by students in general, and students of Prince Faisal Technical College in particular, in their possession of the concepts of coordinate geometry through the use of mathematics teachers with new teaching methods, and highlighting the use of helpful teaching methods, The results of the study also benefit mathematics teachers to benefit from the SOLO taxonomy levels in various fields of mathematical content.

There are no statistically significant differences between the arithmetic means of the scores of the students of the experimental group who studied using the SOLO taxonomy levels method and the arithmetic means of the scores of the controlled group students who studied by the usual method on the acquisition of coordinate geometry concepts test. This research presents novelty by using Solo taxonomy levels of classification in teaching mathematics, designing a teaching strategy to enable students to acquire concepts of coordinate geometry so that it is easy for teachers to implement this strategy in teaching mathematics. The study was limited to Prince Faisal Technical College students studying mathematics for the 2023/2024 AD academic year. The study was also limited to the study tools prepared by the researcher and the values of their validity and reliability. It consisted of preparing a test for acquiring concepts consisting of (15) items and was limited to the test results for acquiring concepts of coordinate geometry. The study was limited to geometry in the mathematics course for students of Prince Faisal Technical College, all of whom are males, their ages range between (19-20) years, and they have completed secondary school.

The study population consists of all Prince Faisal Technical College students studying mathematics for the academic year 2023/2024 AD. Where two groups (experimental and controlled) were chosen from the study population to represent the members of the study, and the method of selecting the two groups was carried out according to the following procedures: The first group, as an experimental group, is taught according to SOLO taxonomy levels, and the second group as a controlled group is taught according to the usual method. Table 2 shows the distribution of study personnel by group.

Table 2. Distribution of participants by group.

Group	Controlled group	Experimental group	Total
Number of students	26	25	51

RESEARCH METHOD

The researcher relies on the semi-experimental approach with two groups (experimental and controlled) and applies a pre and post-test to answer the main question:

G1: O¬1 X O¬1
G2: O¬1 – O¬1
Where:
G1 : the experimental group, G2: the controlled group
X: processing (SOLO taxonomy levels)
O1: pre and post-coordinate geometry concepts acquisition test.

This study includes the following variables: The independent variable is the method of teaching (the SOLO taxonomy levels and the usual method). The dependent variable is acquiring the concepts of coordinate geometry, which is measured by the student's score on the prepared test on the subject of coordinate geometry for the study.

To verify the equivalence of the groups, the arithmetic means, standard deviations of the levels, and total scores of the pre-test scores were extracted according to the group variable (experimental, Controlled). To show the statistical differences between the arithmetic means, the "t" test was used. Table 3 shows the group variable on the dimensions and the total score of the student's scores on the SOLO level taxonomy test scale.

Table 3. Arithmetic means, standard deviations, and the "t" test.

Levels	Group	Number	Arithmetic Mean	Standard Deviation	"t" Test	Free Degree	Statistical Significance
Pre-Structural	Experimental	25	2.28	.84	.91	50	.36
	Controlled	26	2.07	.78			
Uni-Structural	Experimental	25	1.80	.76	.42	50	.67
	Controlled	26	1.70	.86			
Multi-Structural	Experimental	25	1.56	.82	-.53	50	.59
	Controlled	26	1.67	.62			
Relational	Experimental	25	1.20	.76	-.60	50	.55
	Controlled	26	1.33	.83			
Extended	Experimental	25	1.04	.79	-.15	50	.88
	Controlled	26	1.07	.82			
All	Experimental	25	7.88	1.50	.06	50	.94
	Controlled	26	7.85	1.48			

Based on Table 3, no statistically significant differences ($\alpha = 0.05$) are attributed to the group in all dimensions and the total score --- pre-test. This result indicates the equality of the groups. The researcher prepared the educational material based on the SOLO taxonomy levels by reviewing the sources and references that referred to the SOLO taxonomy levels, where the subject of geometry is approved in the mathematics course book. The topic includes the following lessons: the distance between two points, the coordinates of the midpoint of a straight segment, and the equation of a straight line. The three lessons were taught gradually from the SOLO taxonomy levels, starting from the first pre-construction to the last expansion level.

The topic of coordinate geometry was relied upon in conducting this study, and the topic includes three lessons: the distance between two points, the coordinates of the midpoint of a straight segment, and the equation of a straight line. The study includes a test tool for the acquisition of coordinate geometry concepts in mathematics, and it aims to know the degree of student's acquisition of the concepts of coordinate geometry. It is contained in the subject of "Geometry, "which is included in the mathematics book for Prince Faisal Technical College students. The test consists of (15) items. The test was built according to SOLO taxonomy levels, and the researcher relied on classifying concepts into pre-structural level (3 items), uni-structural level (3 items), multi-structural level (3), relational level (3 items), and extended abstract level (3 items).

Using the SPSS program, the responses of a group outside the study sample (25) were analyzed to calculate the difficulty and discrimination coefficients for the test items. The percentage of students who answered the paragraph incorrectly was taken as the difficulty coefficient for each test item. In contrast, the discrimination coefficient was calculated for each item in the form of the item's correlation with the total score. Table 4 shows the difficulty coefficients and discrimination coefficients for each test item.

Table 4. Difficulty and discrimination coefficients for items.

Items	Difficulty coefficients	Discrimination coefficients
1	0.44	.40(*)
2	0.40	.47(**)
3	0.48	.56(**)
4	0.48	.55(**)
5	0.48	.70(**)
6	0.32	.52(**)
7	0.32	.55(**)
8	0.48	.44(*)
9	0.56	.59(**)
10	0.60	.54(**)
11	0.20	.41(*)
12	0.44	.40(*)
13	0.52	.43(*)
14	0.68	.55(**)
15	0.68	.48(**)

It is noted from Table 4 that the difficulty coefficients of the paragraphs ranged between (0.20-0.68), and the discrimination coefficients ranged between (0.40-0.70). The acceptable range for the difficulty of a paragraph is between (0.20-0.80) as for the discrimination of the paragraph, as the paragraph is considered good if its discrimination coefficient is higher than (0.39), and it is acceptable and it is recommended to improve it if its discrimination coefficient ranges between (0.20-0.39), and it is weak and it is recommended to delete it if its discrimination coefficient ranges between (0-0.19), and harmful discrimination should be deleted. Accordingly, all the paragraphs were retained based on the difficulty and discrimination coefficients.

In order to verify the validity of the test, it was presented to a group of arbitrators who hold a PhD in mathematics curricula and teaching methods, specializing in measurement and evaluation. Several educational supervisors where were asked to judge the test items in terms of Taxonomy of knowledge, learning outcomes, linguistic integrity, and output, and in the light of observations and suggestions, The arbitrators have made the necessary adjustments, such as rephrasing some paragraphs, determining the paragraph's correlation with the level, and the ability of the paragraphs to be measured. All required modifications have been made.

To ensure the reliability of the test, it was verified using the test-retest method by applying the test and re-applying it after two weeks to a group outside the study sample consisting of (25) students, and then the Pearson correlation coefficient was calculated between their estimates of the two times. It reached (0.90) for the test as a whole. The reliability coefficient was also calculated using the internal consistency method according to the Kuder-Richardson-20 equation, as it reached (0.84) for the test as a whole, and these values were considered appropriate for this study.

The researchers followed a set of steps to implement this study:

1. Review of previous literature related to SOLO taxonomy levels and coordinate geometry.
2. The educational material was developed based on the SOLO taxonomy levels to be applied during the study period.
3. The study participants were identified, and two classes were selected from Prince Faisal Technical College, taught by one teacher. The subjects were randomly distributed into an experimental and a controlled group.
4. The equivalence of the groups was verified before conducting the study by relying on the results of the acquisition of coordinate geometry concepts test.
5. The teacher who teaches the two groups (experimental and controlled) was trained on applying the SOLO taxonomy levels and its method of implementation during the study period, where the teacher was assigned to teach the subjects covered by the "Coordinate Geometry" unit, where the experimental group was taught according to the SOLO taxonomy levels, while the students of the group The controlled subjects were taught the same unit in the usual way.
6. The duration of the application took two weeks, equivalent to (6) classroom lessons, with two periods for each lesson, and the application took place between 2/9/2023 AD and 16/9/2023 AD.
7. The teacher was followed up and directed during the implementation of the study.
8. After completing the study's implementation, the test of acquiring the concepts of coordinate geometry was applied to the study members as a post-measurement, correcting the test, emptying the results for data analysis, and answering the study question.

To answer the study's question, One-way ANCOVA and One-way MANCOVA were used to find the significance of the differences in the study students' scores in the test of acquiring concepts of coordinate geometry for the experimental and controlled groups.

RESULTS AND DISCUSSION

Results

To answer this question, Table 5 shows the calculated arithmetic means, standard deviations, and adjusted arithmetic mean of the students' scores on the SOLO taxonomy levels scale in the pre- and post-measurements according to the group (experimental, control).

Table 5. Arithmetic means standard deviations and adjusted arithmetic mean of students' scores on the SOLO taxonomy levels scale for the pre- and post-measurements according to the group (experimental, control).

Groups	Pre-Measurements		Post-Measurements		Adjusted Arithmetic Mean	Errors
	Arithmetic Mean	Standard Deviation	Arithmetic Mean	Standard Deviation		
Experimental	7.88	1.50	12.44	1.35	12.43	.28
Controlled	7.85	1.48	9.59	1.60	9.59	.27

Table 5 shows apparent differences between the arithmetic mean and the adjusted arithmetic mean of the student's scores on the SOLO taxonomy levels Scale in the pre- and post-measurements according to the group (experimental, control). To find out whether these apparent differences are statistically significant, the accompanying One-way ANCOVA for the post-measurement of the SOLO taxonomy levels Scale according to the group (experimental, control) after neutralizing the effect of their pre-measurement likely in Table 6.

Table 6. One-way ANCOVA results for the post-measurement of the student's grades, the SOLO taxonomy levels scale, according to the group (experimental, control) after neutralizing the effect of their pre-measurement.

Source of variance	Sum of squares	Degrees of freedom	Mean sum of squares	F value	Significance level	Eta square η2
Pre-measurement	11.36	1	11.36	5.60	.02	.10
group	104.57	1	104.57	51.59	.00	.51
error	99.31	49	2.02			
Total	215.92	51				

It is clear from Table 6 that there are statistically significant differences at the significance level ($\alpha = 0.05$) in the student's scores on the SOLO taxonomy levels scale according to the group (experimental, control). The value of (F) reached (51.59), a statistically significant value. The differences were in favor of the experimental group compared to members of the control group. It is also clear from Table 6 that the effect size of the teaching method was large. The Eta square value (η2) explained (51.30%) of the explained (predicted) variance in the dependent variable, which is the SOLO taxonomy levels measure. The arithmetic means, standard deviations, and adjusted arithmetic mean were also calculated for the pre-and post-measurements of the dimensions of the SOLO taxonomy levels Scale according to the group (experimental, control), as shown in Table 7.

Table 7. Arithmetic means standard deviations and adjusted arithmetic mean for the pre-and post-measurements of the dimensions of the SOLO taxonomy levels scale.

Levels	Group	Number	Pre-Measurements		Post -Measurements		Adjusted Arithmetic Mean	Errors
			Arithmetic Mean	Standard Deviation	Arithmetic Mean	Standard Deviation		

Pre-Structural	Experimental	25	2.28	.84	2.96	.20	2.93	.08
	Controlled	26	2.07	.78	2.56	.57	2.58	.08
Uni-Structural	Experimental	25	1.80	.76	2.88	.33	2.86	.12
	Controlled	26	1.70	.86	2.19	.87	2.20	.11
Multi-Structural	Experimental	25	1.56	.82	2.60	.50	2.63	.11
	Controlled	26	1.67	.62	1.89	.69	1.85	.10
Relational	Experimental	25	1.20	.76	2.16	.89	2.20	.13
	Controlled	26	1.33	.83	1.63	.79	1.58	.13
Extended	Experimental	25	1.04	.79	1.84	.80	1.85	.13
	Controlled	26	1.07	.82	1.33	.78	1.31	.12

Table 8 notes that the arithmetic means and the adjusted arithmetic mean in the pre- and post-measurements of the dimensions of the SOLO taxonomy levels Scale appear to differ based on the group (experimental, control). To verify the significance of the apparent differences, a MANCOVA was applied, as shown in Table 8.

Table 8. One-way MANCOVA for the effect of group on the post-measurement of each dimension of the SOLO taxonomy levels Scale after neutralizing the effect of their pre-measurement.

Source of variance		**Sum of squares**	**Degrees of freedom**	**Mean sum of squares**	**F value**	**Significance level**	**Eta square η2**
Pre-measurements (accompanying)	pre- structural	.44	1	.44	2.32	.13	.04
	Uni- structural	2.93	1	2.93	7.78	.008	.14
	Multi-structural	2.18	1	2.18	6.89	.01	.13
	Relational	11.12	1	11.12	23.54	.00	.34
	Extended	8.86	1	8.86	20.23	.00	.31
The group hotelling = 1.30 h=.00	pre- structural	1.58	1	1.58	8.35	.006	.15
	Uni- structural	5.47	1	5.47	14.52	.00	.24
	Multi-structural	7.54	1	7.54	23.87	.00	.34
	Relational	4.76	1	4.76	10.07	.003	.18
	Extended	3.71	1	3.71	8.48	.006	.15
Errors	pre- structural	8.52	45	.18			
	Uni- structural	16.95	45	.37			
	Multi-structural	14.22	45	.31			
	Relational	21.26	45	.47			
	Extended	19.71	45	.43			
Corrected	pre- structural	11.75	51				
	Uni- structural	28.98	51				
	Multi-structural	25.23	51				
	Relational	39.30	51				
	Extended	34.69	51				

Discussions

It became clear through the results of the statistical analysis that there is a positive effect of using the SOLO taxonomy levels scale as a whole on students' acquisition of coordinate geometry concepts; it is also consistent that there are differences between students' scores on the SOLO taxonomy levels separately, as the SOLO taxonomy levels are based on developing the acquisition of mathematical concepts systematically from the unadorned stage to the complex stage, and the transition from the concrete to the abstract, which was reflected in the development of the educational process. The SOLO taxonomy levels helped to bring about positive and meaningful learning, depending on the student's abilities to link previous mathematical concepts and coordinate geometry concepts (Abrahamson et al., 2020; Azid et al., 2022; Bosse et al., 2021; Kilicoglu & Kaplan, 2022; Singh et al., 2023), which helped me to understand more profound concepts and think at a high level (evaluation, creativity). Students' states of thinking develop because the SOLO taxonomy describes levels of progressively complex understanding through five general stages.

The activities carried out by the teacher also played an essential role in applying the SOLO taxonomy levels, explaining how to move from the pre-structure level to the next level, reaching the expansion level. For example, The teacher asked the students to designate the points on the coordinate plane. He moved on to measuring the line segment using the coordinates, determining the type of triangle resulting from connecting the critics on the coordinate plane, and then deducing the rule for the distance between two points. This was not available to the control group that was usually studied, as the transition was made to the concepts of coordinate geometry in a way that needed to be organized sequentially, as in the SOLO taxonomy levels.

This is what the study by Elazzab & Kacar (2020) indicates: the majority of students may succeed in moving between the levels of the Solo classification. On the contrary, most of the students were unable to find a link between the algebraic concepts they learned and the non-routine problem (Agustyaningrum et al., 2020; Andrade & Pasia, 2020; Augusto et al., 2022; Chirove & Ogbonnaya, 2021; Gözde, 2020; Leow & Kaur, 2024). SOLO taxonomy levels made it possible to measure the degree to which students acquired coordinate geometry concepts and to determine the degree of academic progress achieved. Organizing the concepts of coordinate geometry in an organized manner increased students' motivation to learn. It removes the difficulty in linking concepts and attracts students' attention to further learning, avoiding feelings of boredom and negativity.

The experimental group benefited from teaching using SOLO taxonomy and progressed between its five levels by developing a deeper understanding of coordinate geometry. It also allows the student to develop his knowledge and skills beyond the course's content and link it to other fields and the progression in levels of thinking, starting with understanding and comprehension, reaching the levels of evaluating and issuing judgments on their learning. SOLO taxonomy also helps mathematics teachers design activities and learning strategies to implement these learning outcomes (Ukobizaba et al., 2021). It also raises the level of motivation among students of various types: internal, social, and achievement. It encourages self-learning, as it enables students to take responsibility for their learning and allows them to measure academic progress.

CONCLUSIONS

Fundamental Findings: The use of solo taxonomy in teaching mathematics has a positive impact, especially in acquiring the concepts of coordinate geometry. Geometry is one of the Jordanian curriculum's most prominent mathematical content fields. **Implications**: Teachers can use this strategy in teaching mathematics according to the five successive levels that start from simple to abstract concepts. **Limitations**: The positive effect of this strategy occurred after training the teacher to implement the Solo Taxonomy levels in teaching mathematics. **Further research:** The study suggests conducting further studies on the impact of this strategy on students' acquisition of mathematical concepts in other fields, such as algebra, probability, and others.

Acknowledgments

We thank the reviewers who reviewed the Research Instrument, the school administration, and the students participating in this research.

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