IJERE International Journal of Educational Research Review

International Journal of Educational Research Review

Analysis of the Learning Outcomes of the Türkiye Century Education Model High School Biology Course Curriculum According to SOLO Taxonomy

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This study aims to examine the learning outcomes of the Türkiye Century Education Model High School Biology Course Curriculum, which has been gradually implemented in Türkiye since 2024, according to the SOLO taxonomy. The document analysis method, a qualitative research method, was used in the study. The research data were analyzed using a descriptive analysis approach. At the end of the study, it was determined that the learning outcomes of the program were mostly at the relational and extended abstract levels of the SOLO taxonomy. According to the analysis results, the fewest learning outcomes are at the unistructural level of the SOLO taxonomy, while the most learning outcomes are at the extended abstract level. The analysis results based on the themes of the curriculum show that there are no learning outcomes at the unistructural level in the "Response" theme, at the unistructural and multistructural levels in the "Homeostasis" theme, and at the multistructural level in the "Gene" theme. According to the analysis results in terms of grade level, it was determined that the learning outcomes at the extended abstract level increased with grade level, but the number of learning outcomes at the extended abstract level in the 12th grade was less than the number of learning outcomes at the extended abstract level in the 11th grade. As suggestions, the number of learning outcomes at the unistructural and multistructural levels in the general curriculum and in the themes of "Response," "Homeostasis," and "Gene" can be increased. Additionally, learning outcomes at the extended abstract level of the SOLO taxonomy can be expanded for the 12th grade level.

Keywords: Türkiye Century Education Model, High School Biology Course Curriculum, SOLO taxonomy

INTRODUCTION

In the current century, developments in scientific, economic, and technological fields have led to changes in the characteristics of individuals needed by societies and have necessitated the development of countries' education systems (Polat, Bilen & Kayacan, 2022). Büyükalan Filiz & Yıldırım (2019) stated that qualified individuals needed by societies are trained through planned education conducted with a curriculum, and therefore emphasized the great importance of the curriculum in raising individuals with the requirements of the age. The educational program, which is used together with or interchangeably with the concept of curriculum, is *"a set of learning experiences provided to the learner through planned activities in and out of school."* (Demirel, 2012, p. 6). The educational program consists of four main components: objectives (goals), content, educational situations, and evaluation (Kıroğlu, 2017). The objective is the most important element of an educational program as it directs the learning-teaching process and determines the qualities of this process (Çerçi, 2018). In Türkiye Century Education Model (TYMM), which started to be implemented gradually from the 2024-2025 academic year in Türkiye, objectives are expressed as learning outcomes. *"Learning outcomes, which explain what students who have completed a specific educational process are expected to know, understand, and be able to do, are an important component used as a reference to guide learning-teaching activities and to ensure the evaluation of learning."* (Ministry of National Education [MEB], 2025, p. 32).

Taxonomies are utilized when creating and writing the objectives of educational programs (Bursa, 2022). According to Krathwohl (2002, p. 212) *"the taxonomy of educational objectives is a framework for classifying statements of what we expect or intend students to learn as a result of instruction."* The classification of objectives began with Bloom and his colleagues in the 1950s, and since then, objectives have been classified using various taxonomies (Arı, 2013). Among these taxonomies, Bloom's taxonomy is the most widely accepted (Polat & Turan, 2020). Upon the assertion that there were some deficiencies in Bloom's classification, the Solo taxonomy was developed as an alternative to Bloom's taxonomy (Dönmez & Zorluoğlu, 2020).

Solo Taxonomy

The SOLO taxonomy, initially developed by J.B. Biggs and K. Colins, stands for "Structure of Observed Learning Outcomes" (Arı, 2013). The SOLO taxonomy is an approach used in evaluating and classifying cognitive performance by considering observed learning outcomes (Chick, 1998). Developed based on Piaget's cognitive developmental model, the SOLO taxonomy allows for the explanation of increasing complexity of understanding and the evaluation of cognitive learning outcomes (Adeniji, Baker & Schmude, 2022). The SOLO taxonomy is used not only in writing learning outcomes but also in classifying responses (O'Neill &

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Murphy, 2010). Newton & Martin (2013) stated that the SOLO taxonomy could be useful in teaching as it uses progressive levels in developing exam questions and learning objectives.

The SOLO taxonomy consists of five levels in order of increasing structural complexity: pre-structural, unistructural, multistructural, relational, and extended abstract (Brabrand & Dahl, 2009). The pre-structural level, which is the first level of the SOLO taxonomy, is the lowest step and has a very low level of understanding (Köse, 2018). Responses at this level are irrelevant answers, inadequate understanding, or repetition of elements unrelated to the task (Adeniji, Baker & Schmude, 2022). At the unistructural level, the student can address a single aspect. The student can use terminology, read by rote, perform simple instructions/algorithms, define, name, or count (Brabrand & Dahl, 2009). At the multistructural level, the student focuses on several relevant points but does not show an awareness of the relationships between them or the whole (Jimoyiannis, 2011). Those at this level have difficulty solving problems as they cannot form a coherent whole of the problem (Köse, 2018). The relational level is where multiple ideas are brought together to form a coherent whole. Responses given at this level indicate the use of higher-order thinking (Adeniji, Baker & Schmude, 2022). At the extended abstract level, which is the highest step of the SOLO taxonomy, solutions far beyond existing knowledge are presented, hypotheses are produced and generalizations are made, and an existing theory can be applied to a different field and analyzed in depth (Köse, 2018).

The five levels of the SOLO taxonomy mean that students can structure their answers to questions in five different ways (Gezer & İlhan, 2015). To explain with examples from biology, at the pre-structural level, a student cannot answer any biology questions. At the unistructural level, a student can state the definition of the concept "Species". At the multistructural level, a student can list the common characteristics of living organisms in bullet points. At the relational level, a student can compare the similarities and differences between sexual and asexual reproduction. At the final level, which is the extended abstract level, a student can propose solutions to the increasing water scarcity in recent years.

The SOLO taxonomy has a hierarchical structure where each structure builds upon further learning. In the SOLO taxonomy, where learning progresses from quantitative to qualitative, the pre-structural, uni-structural, and multi-structural levels are quantitative, while the relational and extended abstract levels are qualitative (Biggs & Tang, 2011). Learning is superficial at the quantitative level, whereas it is more in-depth at the qualitative level (Yaralı, 2025). The SOLO taxonomy, which aims to reveal the qualitative aspect of learning outcomes rather than the quantitative aspect, is a highly suitable model for evaluating learning outcomes as it was developed to cognitively assess students' levels of understanding in a field (Doğan, 2020).

When examining the literature, it is observed that the SOLO taxonomy is frequently used in evaluating the learning outcomes and objectives of curricula (Alsaadi, 2001; Gezer & İlhan, 2014; Gezer & İlhan, 2015; Göçer & Kurt, 2016; Ağçam & Babanoğlu, 2018; Doğan, 2020; Dönmez & Zorluoğlu, 2020; Acet, Acet & Kurnaz, 2021; Erbaş, 2021; Hasırcı Aksoy, 2021; Bursa, 2022; Dilekçi, 2022; Kayacan, 2022; Öner, 2022; Polat, Bilen & Kayacan, 2022; Acar & Peker, 2023; Aktı Aslan, 2023; Arı, 2023; Triana et al., 2023). Furthermore, there are studies in the literature that examine the learning outcomes of TYMM curricula in Türkiye according to the SOLO taxonomy (Cihan & Doruk, 2024; Kunt & Yılmaz Bursa, 2024; Satmaz & Yabanova, 2024; Diktaş et al., 2025; Kılıç, 2025; Yaralı, 2025; Yılmaz, 2025). However, no study has been found in the literature that examines the learning outcomes of the TYMM High School Biology Course Curriculum according to the SOLO taxonomy.

TYMM High School Biology Course Curriculum

The High School Biology Course Curriculum, structured based on the TYMM Common Text, has been prepared in response to the increasing need for biology and biology education, which has become an important part of daily life, especially with developments in the fields of molecular biology and biotechnology. The prepared Biology Course Curriculum aims to awaken curiosity about the world of living things in students and to demonstrate why learning biology is necessary (MEB, 2024). The learning outcomes of the program, which were expressed as acquisitions in the previous curriculum, have been prepared in relation to

the field skills, conceptual skills, and fundamental topics of biology that students are expected to acquire in the biology course. The content of the curriculum has been structured with care to relate topics to daily life problems and thereby support students in making inferences. This allows students to relate the knowledge they acquire within the scope of both learning outcomes and inter-program components to daily life (MEB, 2024).

Determining the cognitive levels of learning outcomes in a curriculum is one of the important steps in assessing the effectiveness of the implemented program (Gezer & İlhan, 2015). Therefore, this study aims to analyze the learning outcomes in the TYMM High School Biology Course Curriculum using the SOLO taxonomy. In this way, it is aimed to contribute to the organization of learning experiences that will facilitate the achievement of the desired goals of the TYMM High School Biology Course Curriculum, to evaluate the level of goal attainment, and to contribute to future curriculum development efforts. It is believed that the findings obtained at the end of the study will contribute to the literature. In this context, the study will seek answers to the following research questions:

1. How are the learning outcomes of the TYMM High School Biology Course Curriculum distributed according to the levels of the SOLO taxonomy?

2. How are the learning outcomes of the TYMM High School Biology Course Curriculum distributed according to the levels of the SOLO taxonomy in terms of grade levels?

3. How are the learning outcomes of the TYMM High School Biology Course Curriculum distributed according to the levels of the SOLO taxonomy in terms of the curriculum's themes?

METHOD

In this part, the design of the study, the data collection tools and information about the analysis of the data are given.

Research Design

In the study aimed at examining the learning outcomes in the TYMM High School Biology Course Curriculum using the SOLO taxonomy, the document analysis method, one of the qualitative research methods, was used. The document analysis is a method that involves the analysis of written materials containing information about the phenomena or events to be researched. In this method, the researcher can obtain the required data by examining written materials without conducting observations or interviews. Thus, the document analysis method provides the researcher with time and cost savings (Yıldırım & Şimşek, 2005). Since the data source of the study consists of the learning outcomes specified in the TYMM High School Biology Course Curriculum (MEB, 2024), the document analysis method was used in the study.

Data Collection Tool

The data for the study were collected using the TYMM High School Biology Course Curriculum (MEB, 2024). The distribution of learning outcomes in the TYMM High School Biology Course Curriculum according to grade level and themes is presented in Table 1.

Table 1. The Distribution of Learning Outcomes and Themes of TYMM High School Biology Course Curriculum

Grade Level	Theme	Number of the Learning Outcomes
9	Life	7
	Organization	8
10	Energy	10
	Ecology	9
11	Response	12
	Homeostasis	10
12	Reproduction	12
	Gene	10
Total		**78**

When examining the TYMM High School Biology Course Curriculum, it is observed that the themes are "Life" and "Organization" for 9th grade, "Energy" and "Ecology" for 10th grade, "Response" and "Homeostasis" for 11th grade, and "Reproduction" and "Gene" for 12th grade. Additionally, in the "School-Based Planning" theme present at each grade level, activities such as out-of-school learning activities, research and observation, social activities, project work, local studies, and reading activities decided to be carried out within the scope of the course are conducted, as well as guidance activities for students' career choice and career planning. The TYMM Biology Course Curriculum includes a total of 78 learning outcomes, with 15 in 9th grade, 19 in 10th grade, and 22 each in 11th and 12th grades (MEB, 2024).

Analysis of The Data

A descriptive analysis approach was used in the analysis of the study data. In this approach, data are summarized and interpreted according to predetermined themes. The data, which are described systematically and clearly, are then explained and interpreted, cause-effect relationships are examined, and certain conclusions are reached (Yıldırım & Şimşek, 2005). In the analysis of the TYMM Biology Course Curriculum learning outcomes according to the levels of the SOLO taxonomy, indicator verbs compiled from the relevant literature by Doğan (2020, p. 2313) were used (Table 2). Since there is no learning situation related to the learning area in the Pre-Structural level, which is the first stage of the SOLO classification, there is no indicator verb defined for this level (Doğan, 2020).

Table 2. Some Indicator Verbs of SOLO Taxonomy (Doğan, 2020, p. 2313)

Levels	Verbs
Unistructural	Explain, transfer, say, sort, count, expressing, remember, notice, name, repeat, diagnose, recognize, mark, memorize
Multistructural	Classify, combine, numerate, list, define, plan, clarifying, symbolise, make clear, qualifying, explain the meaning, attribute metaphorical meaning, follow the algorithm, apply the method
Relational	Distinguish, categorise, questioning, merge, relate, apply, analyze, compare, determine the outlines, predict, evaluate, summarise, observe, integrate, explain the reasons, establish a cause-effect relationship, applying a given theory to the related field
Extended abstract	Design, create, judge, hypothesise, evaluate, discuss, reflect, generalising, theorising, high foresight, examine in depth, applying theory to a new field

The learning outcomes of the TYMM Biology Course Curriculum for grades 9, 10, 11, and 12 have been analyzed using the verbs presented in Table 2. An example of learning outcome analysis from each grade level is provided in Table 3.

Table 3. Examples of Learning Outcome Analysis

Grade Level	Learning Outcomes	SOLO Level
9	BIO.9.1.5. To be able to classify living organisms.	Multistructural
10	BIO.10.1.4. To be able to collect information about chemosynthesis.	Unistructural
11	BIO.11.1.1. To be able to reason inductively about the response mechanisms of different organisms to stimuli.	Extended abstract
12	BIO.12.1.4. To be able to question cell cycle and cell division in living organisms.	Relational

According to the TYMM Biology Course Curriculum, students are expected to be able to classify based on the learning outcome BIO.9.1.5. According to Table 2, classification is placed at the multi-structural level of the SOLO taxonomy. In the learning outcome BIO.10.1.4, students are expected to gather information. Information gathering is considered a simple learning related to only one aspect of a subject and is classified at the uni-structural level. In the learning outcome BIO.11.1.1, students are expected to use inductive reasoning. As this learning outcome involves generalizing from specific to general, BIO.11.1.1 is evaluated at the extended abstract stage (Table 2). Since the learning outcome BIO.12.1.4 includes the action of questioning, according to Table 2, this learning outcome is placed at the relational level of the SOLO taxonomy.

Validity and Reliability

Validity and reliability in qualitative research are evaluated differently from quantitative research (Kılıç, 2025). There are certain criteria that need to be met to ensure validity and reliability in qualitative research (Yıldırım & Şimşek, 2005). In this study, to ensure validity and reliability, the results obtained were reported in detail using tables and graphs. The verbs used in coding learning outcomes are presented in Table 2. Additionally, the data analysis process was described in detail, and examples of coding learning outcomes were also included. The study data were coded separately by two faculty experts, one of whom is the author of the study, both experts in the field of biology education and having previously conducted studies on cognitive domain classification. Before expert opinion, the researcher informed the other faculty member, who was the coder, about the levels of SOLO taxonomy and the classification of learning outcomes according to SOLO taxonomy. To ensure the reliability of the data coded separately by two faculty members, inter-coder agreement was examined. The formula Reliability = (agreement) / (agreement + disagreement) was used to calculate inter-coder agreement (Miles & Huberman, 1994, p. 64). As a result of the calculation, the inter-coder agreement was found to be 85.9%. This value being above 80% indicates that the inter-coder agreement is sufficient (Miles & Huberman, 1994).

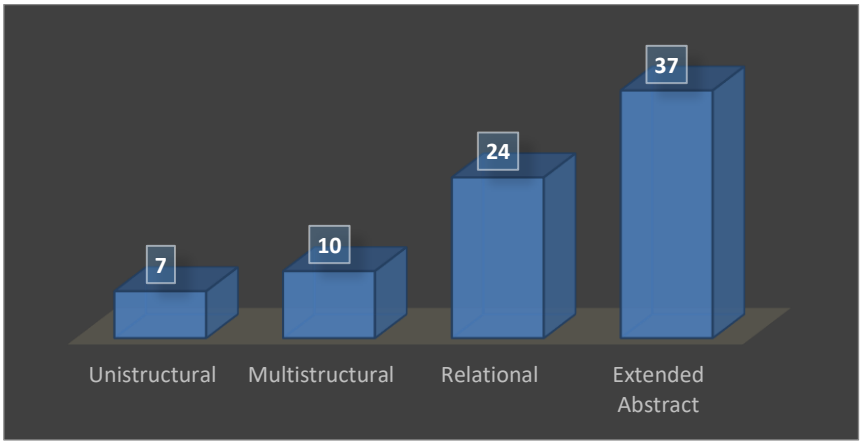
FINDINGS

The findings related to the first research question of the study, which is expressed as "How are the learning outcomes of the TYMM High School Biology Course Curriculum distributed according to the levels of the SOLO taxonomy?", are presented in Table 4 and Graph 1.

Table 4. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels

SOLO Level	f	%
Unistructural	7	8.97
Multistructural	10	12.82
Relational	24	30.77
Extended Abstract	37	47.44
Total	**78**	**100**

Graph 1. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels



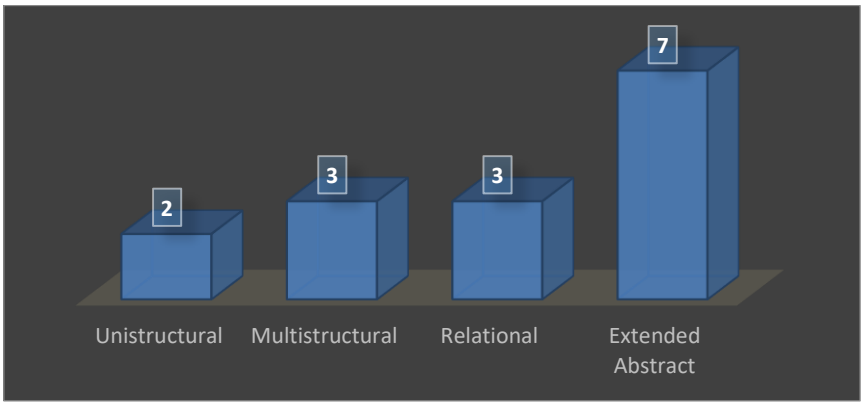
According to Table 4 and Graph 1, 7 (8.97%) of the learning outcomes are at the unistructural level of the SOLO taxonomy, 10 (12.82%) at the multistructural level, 24 (30.77%) at the relational level, and 37 (47.44%) at the extended abstract level. The learning outcomes BIO.9.1.3., BIO.9.2.2., BIO.10.1.4., BIO.10.2.9., BIO.12.1.9., BIO.12.1.10., and BIO.12.2.9. in the curriculum expect students to "Collect Information." In "Information Collection," the focus is on a single area of a topic. Doğan (2020) stated that at the unistructural level, the student identifies a single area to work on and focuses solely on that area. At this level, a student can be taught a single piece, process (method), or concept (Doğan, 2020). Therefore, these learning outcomes have been evaluated at the unistructural level. The learning outcomes "BIO.10.2.5. Ability to interpret the importance of ecological sustainability" and "BIO.11.1.8. Ability to interpret the reflex event" expect students to make interpretations. Being able to interpret requires seeing several different aspects of an event and evaluating it from different perspectives. Since Doğan (2020) stated that at the multistructural level, the student can evaluate situations from several perspectives and provide different interpretations, "Ability to interpret" has been evaluated at the multistructural level. The learning outcome "BIO.11.1.7. Ability to analyze the structure of the human nervous system" is a learning outcome that requires analysis. Since the verb "analyze" is a verb at the relational level in Table 2, this outcome has been evaluated at the relational level. Similarly, the verb "compare" in the learning outcome "BIO.11.2.3. Ability to compare positive and negative feedback mechanisms" is also a verb at the relational level according to Table 2, so this outcome has also been placed within the relational level. The learning outcomes "BIO.11.1.10 Ability to create a scientific model related to the contraction and relaxation mechanism of skeletal muscles" and "BIO.12.2.2. Ability to create a scientific model of DNA replication" contain the verb "create," which is related to the extended abstract level, so these learning outcomes have been evaluated at the extended abstract level (Table 2).

To answer the second research question of the study, which is expressed as "What is the distribution of the learning outcomes of the TYMM High School Biology Course Curriculum across SOLO taxonomy levels in terms of grade levels?", the analysis results of the 9th Grade learning outcomes of the curriculum according to the levels of SOLO taxonomy are presented in Table 5 and Graph 2.

Table 5. Distribution of 9th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels

Grade Level	SOLO Level	f	%
9	Unistructural	2	13.33
	Multistructural	3	20.00
	Relational	3	20.00
	Extended Abstract	7	46.67
	Total	15	100

Graph 2. Distribution of 9th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels



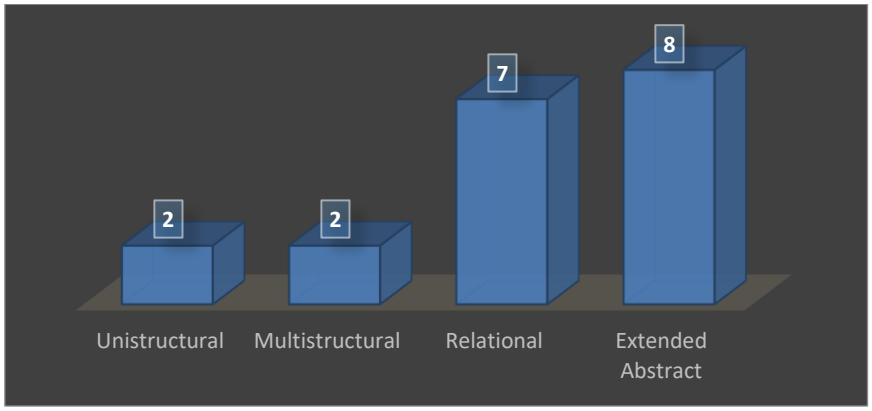
According to the analysis results, 2 (13.33%) of the learning outcomes in the 9th grade of the curriculum are at the unistructural level. While there are 3 (20%) learning outcomes each at the multistructural and relational levels, 7 (46.67%) learning outcomes are at the extended abstract level.

The analysis results of the 10th Grade learning outcomes of the TYMM High School Biology Course curriculum according to the levels of SOLO taxonomy are summarized in Table 6 and Graph 3.

Table 6. Distribution of 10th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels

Grade Level	SOLO Level	f	%
10	Unistructural	2	10.53
	Multistructural	2	10.53
	Relational	7	36.84
	Extended Abstract	8	42.10
	Total	19	100

Graph 3. Distribution of 10th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels



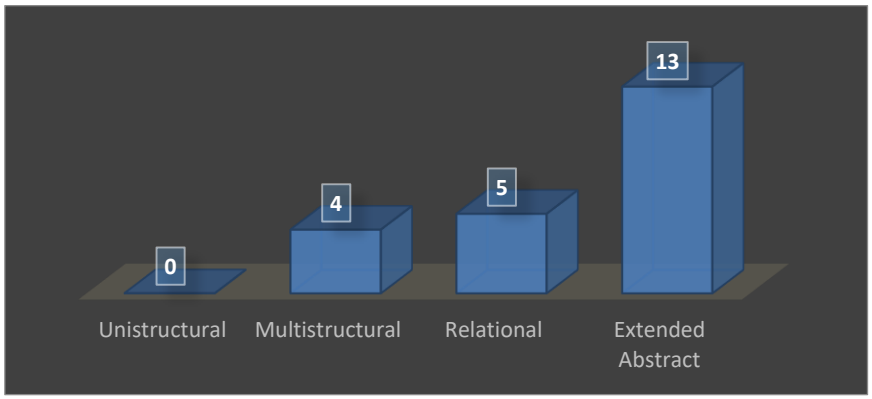
The analysis results show that out of the 10th grade learning outcomes, 2 (10.53%) each are at the unistructural and multistructural levels, 7 (36.84%) are at the relational level, and 8 (42.10%) are at the extended abstract level.

The analysis results of the 11th Grade learning outcomes of the curriculum according to the levels of SOLO taxonomy are presented in Table 7 and Graph 4.

Table 7. Distribution of 11th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels

Grade Level	SOLO Level	f	%
11	Unistructural	-	-
	Multistructural	4	18.18
	Relational	5	22.73
	Extended Abstract	13	59.09
	Total	22	100

Graph 4. Distribution of 11th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels



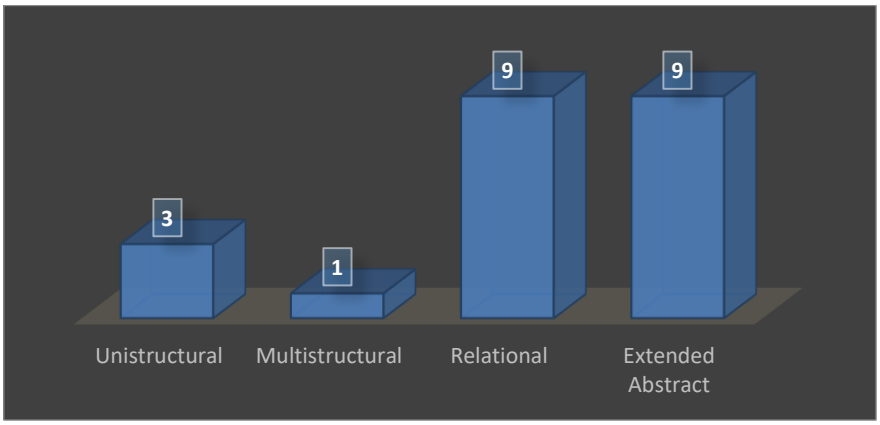
The obtained results indicate that there are no learning outcomes at the 11th grade level in the unistructural level of the SOLO taxonomy. According to the analysis results, the 11th grade curriculum includes 4 (18.18%) learning outcomes at the multistructural level, 5 (22.73%) at the relational level, and 13 (59.09%) at the extended abstract level of the SOLO taxonomy.

The analysis results of the 12th Grade learning outcomes of the TYMM High School Biology Course curriculum according to the levels of SOLO taxonomy are summarized in Table 8 and Graph 5.

Table 8. Distribution of 12th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels

Grade Level	SOLO Level	f	%
12	Unistructural	3	13.63
	Multistructural	1	4.55
	Relational	9	40.91
	Extended Abstract	9	40.91
	Total	22	100

Graph 5. Distribution of 12th Grade Learning Outcomes in the TYMM High Biology Course Curriculum According to SOLO Taxonomy Levels



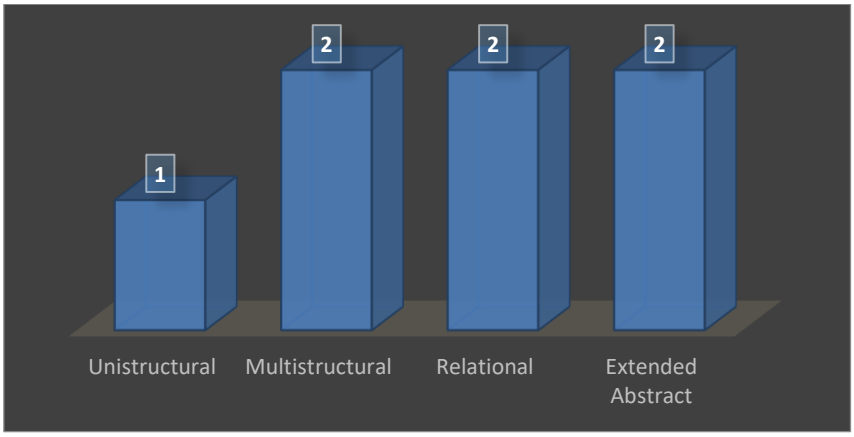
When examining the table and graph, it is observed that out of the learning outcomes at the 12th Grade level in the curriculum, 3 (13.63%) are at the unistructural level of the SOLO taxonomy, 1 (4.55%) is at the multistructural level, and 9 learning outcomes each (40.91%) are at the relational and extended abstract levels.

The third research question of the study is "How are the learning outcomes of the TYMM High School Biology Course Curriculum distributed according to the levels of the SOLO taxonomy in terms of the program's themes?" The findings related to the analysis of the "Life" theme of the curriculum, aimed at answering this research question, are presented in Table 9 and Graph 6.

Table 9. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Life" Theme

Theme	SOLO Level	f	%
Life	Unistructural	1	14.29
	Multistructural	2	28.57
	Relational	2	28.57
	Extended Abstract	2	28.57
	Total	7	100

Graph 6. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Life" Theme



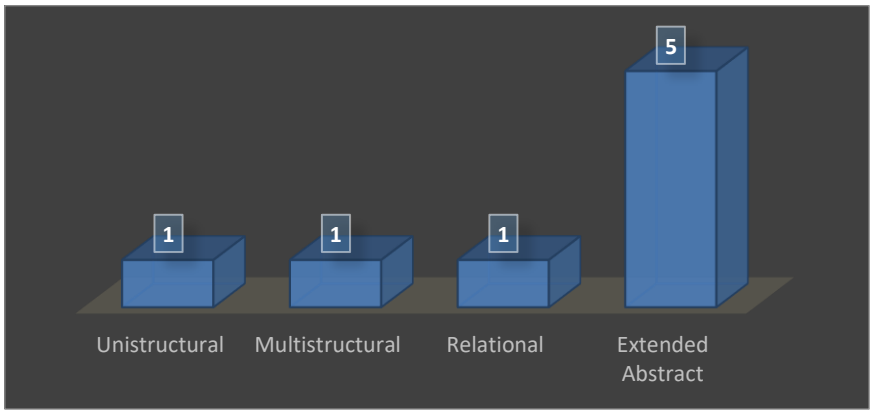
Of the 7 learning outcomes included in the "Life" theme, 1 (14.29%) is in the unistructural level of the SOLO taxonomy; while 2 (28.57%) learning outcomes each are in the multistructural, relational, and extended abstract levels.

The findings related to the analysis of the "Organization" theme of the curriculum are summarized in Table 10 and Graph 7.

Table 10. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Organization" Theme

Theme	SOLO Level	f	%
Organization	Unistructural	1	12.5
	Multistructural	1	12.5
	Relational	1	12.5
	Extended Abstract	5	62.5
	Total	8	100

Graph 7. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Organization" Theme



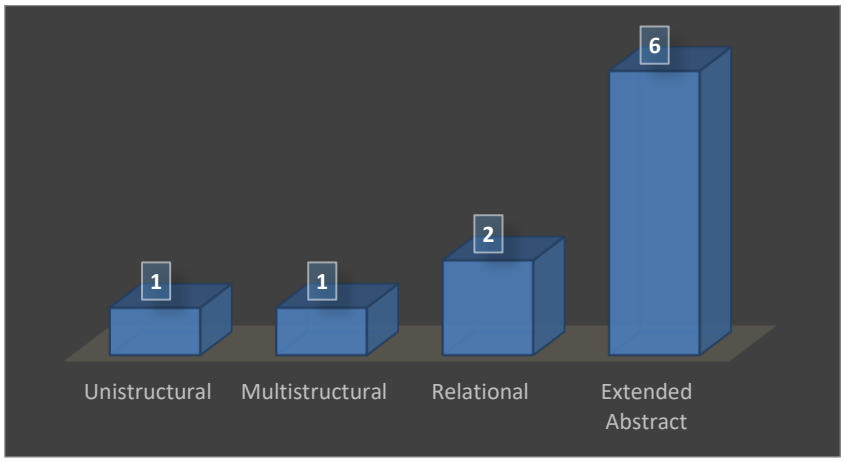
The analysis results show that 1 (12.5%) learning outcome from each of the 8 learning outcomes that constitute the "Organization" theme is found at the unistructural, multistructural, and relational levels of the SOLO taxonomy. In this theme, 5 (62.5%) learning outcomes are at the extended abstract level.

The findings related to the analysis of the "Energy" theme of the curriculum are presented in Table 11 and Graph 8.

Table 11. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Energy" Theme

Theme	SOLO Level	f	%
Energy	Unistructural	1	10
	Multistructural	1	10
	Relational	2	20
	Extended Abstract	6	60
	Total	10	100

Graph 8. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Energy" Theme



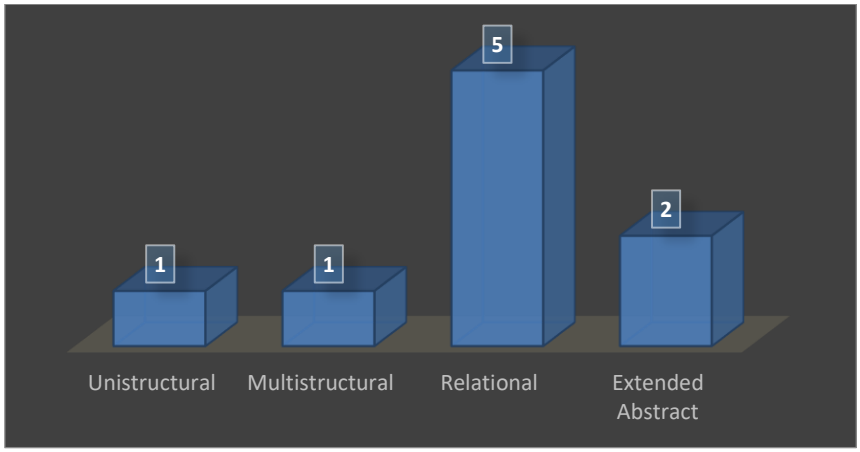
Of the 10 learning outcomes included in the "Energy" theme of the curriculum, 1 (10%) learning outcome is in the uni-structural level, 1 (10%) in the multi-structural level, 2 (20%) learning outcomes are in the relational level, and 6 (60%) learning outcomes are in the extended abstract level.

The analysis results for the "Ecology" theme included in the curriculum are presented in Table 12 and Graph 9.

Table 12. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Ecology" Theme

Theme	SOLO Level	f	%
Ecology	Unistructural	1	11.11
	Multistructural	1	11.11
	Relational	5	55.56
	Extended Abstract	2	22.22
	Total	9	100

Graph 9. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Ecology" Theme



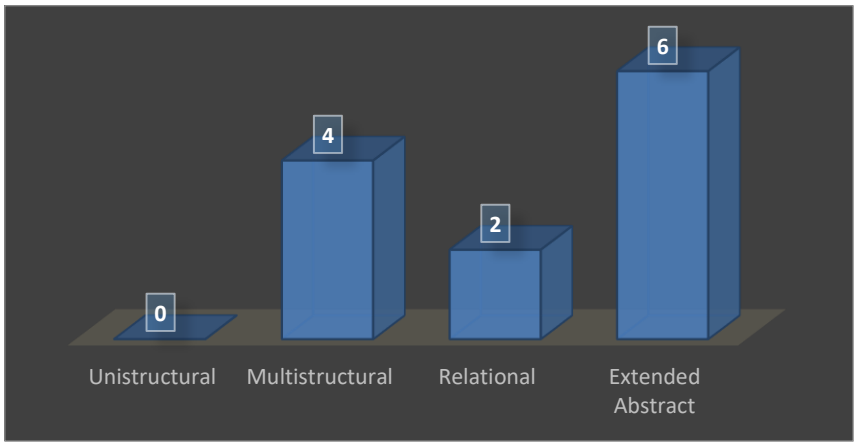
The analysis results show that out of 9 learning outcomes in the "Ecology" theme, 1 (11.11%) learning outcome is at the unistructural level, 1 (11.11%) at the multistructural level, 5 (55.56%) at the relational level, and 2 (22.22%) at the extended abstract level.

The analysis results of the learning outcomes in the "Response" theme are summarized in Table 13 and Graph 10.

Table 13. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Response" Theme

Theme	SOLO Level	f	%
Response	Unistructural	-	-
	Multistructural	4	33.33
	Relational	2	16.67
	Extended Abstract	6	50.00
	Total	12	100

Graph 10. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Response" Theme



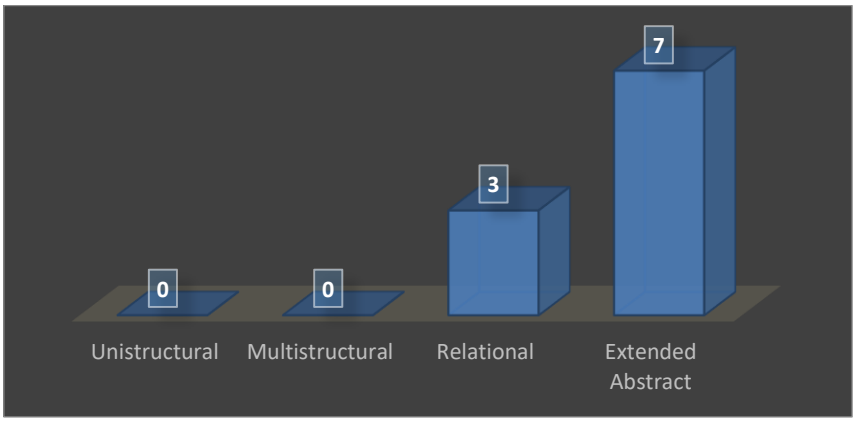
There are no learning outcomes at the unistructural level of the SOLO taxonomy in the "Response" theme. In this theme, there are 4 (33.33%) learning outcomes at the multistructural level, 2 (16.67%) at the relational level, and 6 (50%) at the extended abstract level.

The findings related to the analysis of the "Homeostasis" theme of the curriculum are presented in Table 14 and Graph 11.

Table 14. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Homeostasis" Theme

Theme	SOLO Level	f	%
Homeostasis	Unistructural	-	-
	Multistructural	-	-
	Relational	3	30.00
	Extended Abstract	7	70.00
	Total	10	100

Graph 11. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Homeostasis" Theme



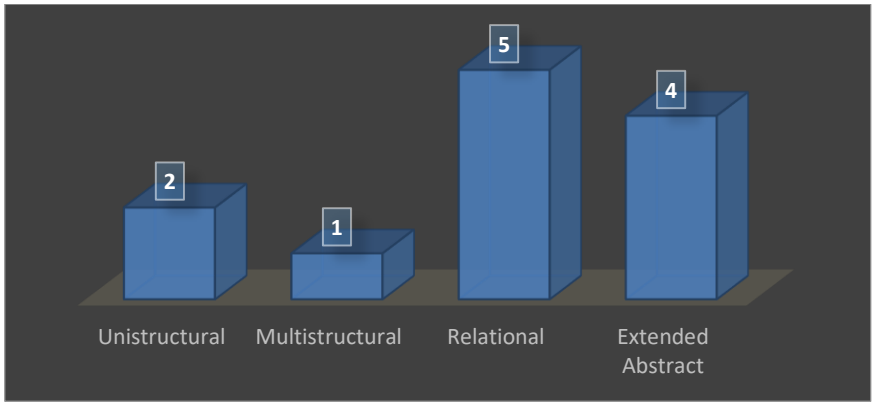
In the "Homeostasis" theme, which has no learning outcomes in the unistructural and multistructural levels of the SOLO taxonomy, there are 3 (30%) learning outcomes at the relational level, while there are 7 (70%) learning outcomes at the extended abstract level.

The analysis results of the learning outcomes for the "Reproduction" theme in the TYMM High School Biology Course Curriculum are presented in Table 15 and Graph 12.

Table 15. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Reproduction" Theme

Theme	SOLO Level	f	%
Reproduction	Unistructural	2	16.67
	Multistructural	1	8.33
	Relational	5	41.67
	Extended Abstract	4	33.33
	Total	12	100

Graph 12. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Reproduction" Theme



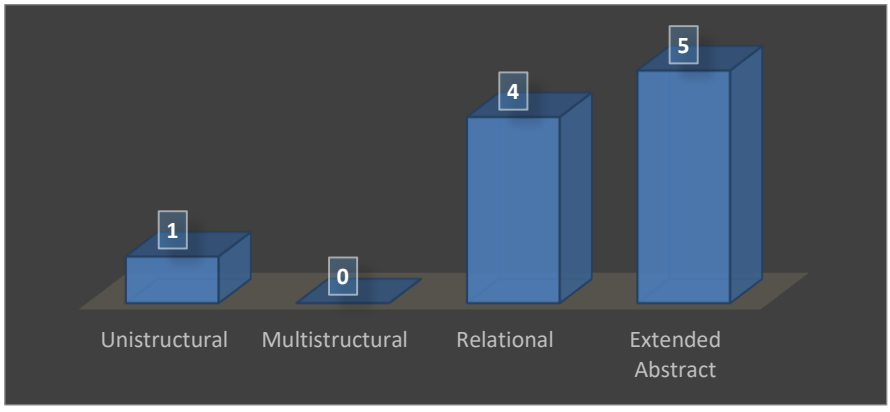
According to the analysis results, out of the 12 learning outcomes included in the "Reproduction" theme, 2 (16.67%) are at the unistructural level, 1 (8.33%) is at the multistructural level, 5 (41.67%) are at the relational level, and 4 (33.33%) are at the extended abstract level.

The analysis results of the learning outcomes included in the "Gene" theme, which is the final theme of the curriculum, are summarized in Table 16 and Graph 13.

Table 16. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Gene" Theme

Theme	SOLO Level	f	%
Gene	Unistructural	1	10.00
	Multistructural	-	-
	Relational	4	40.00
	Extended Abstract	5	50.00
	Total	10	100

Graph 13. Distribution of Learning Outcomes in the TYMM High School Biology Course Curriculum According to SOLO Taxonomy Levels in Terms of the "Gene" Theme



According to Table 16 and Graph 13, in the "Gene" theme, which has no learning outcomes at the multi-structural level of the SOLO taxonomy, there are 1 (10%) learning outcome at the uni-structural level, 4 (40%) at the relational level, and 5 (50%) at the extended abstract level.

RESULT and DISCUSSION

This study aimed to examine the learning outcomes of the TYMM High School Biology Course Curriculum, which has been gradually implemented in Turkey since 2024, according to the levels of the SOLO taxonomy. The analysis results addressing the first research question, "How are the learning outcomes of the TYMM High School Biology Course Curriculum distributed according to the levels of the SOLO taxonomy?", show that the learning outcomes of the program are mostly at the relational and extended abstract levels. At the end of Yaralı's (2025) study, which examined the learning outcomes of the 2024 Chemistry Course Curriculum according to the levels of the SOLO taxonomy, it was stated that the number of learning outcomes at the unistructural and multistructural levels was considerably less than those at the relational and extended abstract levels. According to the analysis results, the least number of learning outcomes are found at the unistructural level of the SOLO taxonomy, while the highest number are at the extended abstract level (Table 4). Similarly, in a study conducted by Cihan & Doruk (2024), it was reported that the majority (62.5%) of the learning outcomes in the 2024 High School Mathematics Course Curriculum were at the extended abstract level. The extended abstract level is where the relationship of knowledge to abstract principles is understood (Biggs & Collis, 1982). Therefore, considering that biology is a difficult subject for students to understand as it mostly contains abstract concepts that cannot be seen with the naked eye (Çimer, 2012), it is necessary for the majority of the learning outcomes in the curriculum to be at the extended abstract level of the SOLO taxonomy. Furthermore, the fact that the learning outcomes of the TYMM High School Biology Course Curriculum are mostly at the relational and extended abstract levels, which reflect qualitative learning (Biggs & Tang, 2011), indicates that the curriculum places more emphasis on learning outcomes that enable students to reconstruct knowledge.

The analysis results of the learning outcomes in the curriculum according to grade levels in terms of SOLO taxonomy levels show that the learning outcomes at the extended abstract level increase with grade level, but the number of learning outcomes at the extended abstract level in 12th grade falls below the number of learning outcomes at the extended abstract level in 11th grade. Similarly, in a study conducted by Cihan & Doruk (2024), it was determined that in the 2024 High School Mathematics Curriculum, the learning outcomes at the extended abstract level increased from the preparatory class to 10th grade, but the number of learning outcomes at the extended abstract level decreased in 11th and 12th grades. This finding obtained at the end of the study is considered important in terms of showing that the learning outcomes at the extended abstract level in the 12th grade of the TYMM High School Biology Course Curriculum are not sufficient. This situation may cause 12th grade students, who have a higher level of cognitive development compared to other grades, to not fully utilize their mental capacities. This is because Doğan (2020) stated that including more outcomes aimed at the relational and extended abstract levels of SOLO taxonomy in the curriculum, especially as grade levels progress, is important in terms of utilizing mental capacity.

The analysis results of the learning outcomes in terms of SOLO taxonomy levels for the themes of the TYMM High School Biology Course Curriculum show that in all 8 themes of the curriculum, learning outcomes at the relational and extended abstract levels are more prevalent than those at the unistructural and multistructural levels. It has been determined that there are no learning outcomes at the unistructural level in the "Response" theme, at the unistructural and multistructural levels in the "Homeostasis" theme, and at the multistructural level in the "Gene" theme of the curriculum. Although the unistructural and multistructural levels are the lowest levels of SOLO taxonomy, they are foundational levels for knowledge. Doğan (2020) stated that to progress on a subject, one must first have knowledge, and that the outcomes at the unistructural level provide basic information about a subject which is a prerequisite for other learning. Therefore, he emphasized that outcomes related to the unistructural level should definitely be included in every curriculum. Additionally, Doğan (2020) indicated that for students to transfer what they have learned to a different area and make connections between subjects, outcomes at the multistructural and relational levels of the SOLO classification should also be included in curricula.

In line with the findings obtained at the end of the study, the number of learning outcomes at the unistructural and multistructural levels in the general curriculum and in the themes of "Response," "Homeostasis," and "Gene" can be increased. Additionally, learning outcomes at the extended abstract level of the SOLO taxonomy can be expanded for the 12th grade level. Furthermore, the previous High School Biology Course Curriculum outcomes can be evaluated in terms of the SOLO taxonomy and compared with the current curriculum.

Moreover, the assessment questions in the textbooks used in high school biology course and the biology questions in the university entrance exam can be examined in terms of the SOLO taxonomy to evaluate whether they are compatible with the curriculum.

Declarations

Conflict of Interest

No potential conflicts of interest were disclosed by the author(s) with respect to the research, authorship, or publication of this article.

Ethics Approval

This study is based on the examination of TYMM High School Biology Course Curriculum according to levels of the SOLO taxonomy. For this reason, it is not one of the studies that require ethics committee approval.

Funding

No specific grant was given to this research by funding organizations in the public, commercial, or not-for-profit sectors.

Research and Publication Ethics Statement

The the author assure that for the manuscript "Analysis of The Learning Outcomes of The Türkiye Century Education Model High School Biology Course Curriculum According to SOLO Taxonomy" the following is fulfilled:

- This material is the authors' own original work, which has not been previously published elsewhere.
- The paper reflects the authors' own research and analysis in a truthful and complete manner.
- The results are appropriately placed in the context of prior and existing research.
- All sources used are properly disclosed.

Contribution Rates of Authors to the Article

Author contributed 100%.

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