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SECONDARY SCHOOL STEAM EDUCATION: CASE STUDY RESEARCH AND PROBLEMS

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Abstract. The effectiveness of STEAM classes in secondary schools is the subject of this article (6-8 Grades). As a result, STEAM education, which incorporates knowledge from science, technology, engineering, art, and mathematics, is becoming more important in preparing students to be 21st-century innovators and investigator. Many educators believe that STEAM education is the most effective educational model for enhancing 21st-century skills and competencies. We administered a questionnaire and conducted a survey to assess secondary school students' and STEAM instructors' perceptions of the STEAM class. A number of concerns have been raised about the pedagogical and methodological components of STEAM lessons in schools. While STEAM programs require students to complete projects, they are not evaluated in terms of science, technology, engineering, art and mathematics. A number of alternative approaches to resolving these issues have been proposed.

Keywords: *Secondary school, STEAM lesson, STEAM project, pedagogy in STEAM.*

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1. Introduction

The twenty-first century is widely regarded as the technological age. This technological breakthrough has led to the advancement of several scientific disciplines. Education is one of these areas. Azerbaijan's educational system's development and strengthening is always a top priority. It also had an impact on how physics was taught in schools. As a result, the literature employs technologies to assist students in developing a deeper understanding of specific physics concepts (Sharifov, 2020, 2021), virtual laboratories for physics instruction (Sharifov, 2020A; Sharifov & MacIsaac, 2021), and Lab Disks (Sharifov & MacIsaac, 2021). (Sharifov, 2020C). Project work has grown in popularity, and a new type of project was proposed to be created in school (Sharifov, 2020B). As a result, educators in our country investigate educational practices in other countries and gradually integrate them into our school system. The STEM lesson is one of these models.

STEAM education, which combines knowledge from science, technology, engineering, art, and mathematics, is gaining popularity as a way to prepare students for success and creativity in the twenty-first century. Many educators believe that STEAM is the most important educational model for acquiring 21st century competencies.

In the early 1990s, STEM curricula were introduced in American schools (Sharifov, 2018). STEM stood for Science, Technology, Engineering, and Mathematics prior to the STEAM movement. Georgette Yakman, a technology educator and engineer, is credited with transforming STEM into STEAM by incorporating arts into the curriculum (Fig.1). He established the STEAM Education Framework in 2006. STEAM is a STEM subset that includes a specific field of study, most notably art (Danielle & Cassie, 2017; Epstein & Fisher, 2017).

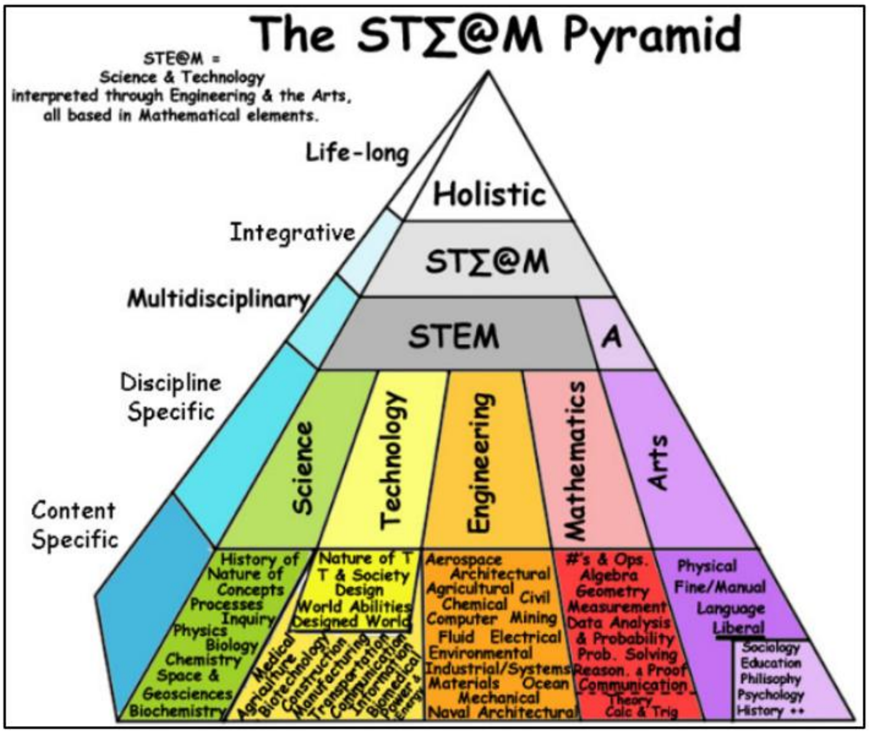

Fig. 1. STEAM pyramid (Yakman, 2008)

STEM programs gained popularity in Europe around 2007. The STEAM pyramid embodies the essence and content of STEAM (Yakman, 2008).

STEAM education research has broadly classified 243 STEAM skills into eight primary categories in the United States, Austria, Belgium, Cyprus, Finland, Ireland, Slovenia, Spain, and Sweden (Mcloughlin *et al.,* 2020):

1 - Problem Solving;
2 - Innovation and Creativity;
3 - Communication;
4 - Critical Thinking;
5 - Metacognitive Skills;
6 - Collaboration;
7 - Self-Regulation;
8 - Disciplinary Competencies.

In developed countries, the STEAM lesson structure is as follows (Lesseig *et al*. 2017). (Figure 2). Despite its popularity, there is insufficient empirical evidence to support promising teaching approaches, and much less is known about instructional issues. Herro et al. (2018) describe the instructional challenges that 33 math and science educators faced while integrating STEAM courses into their classrooms over the course of a year-long professional development program. Pacing issues, student comprehension of topic and process, planning issues, and questions about school district policies were all obstacles. Technology integration and assessment challenges were two less common but still significant impediments. Several factors should be considered by educational scholars and instructors when developing a successful STEAM program. Sanchez and Cortes (2019) discovered that one should strive to promote cross-course collaboration with peers in the same field as well as colleagues from other disciplines. Transdisciplinary courses may provide students with additional skills for dealing with real-world problems by allowing them to approach them from various angles. Mejias et al. (2021) conducted a critical examination of STEAM in order to better understand what STEAM is and what it might be. They claim that contemporary manifestations of STEAM take many forms and are frequently theorized and characterized in divergent and sometimes contradictory directions, having emerged as a developing field of arbitrarily paired disciplines in response to the emergence and subsequent influence of STEM on educational policy.

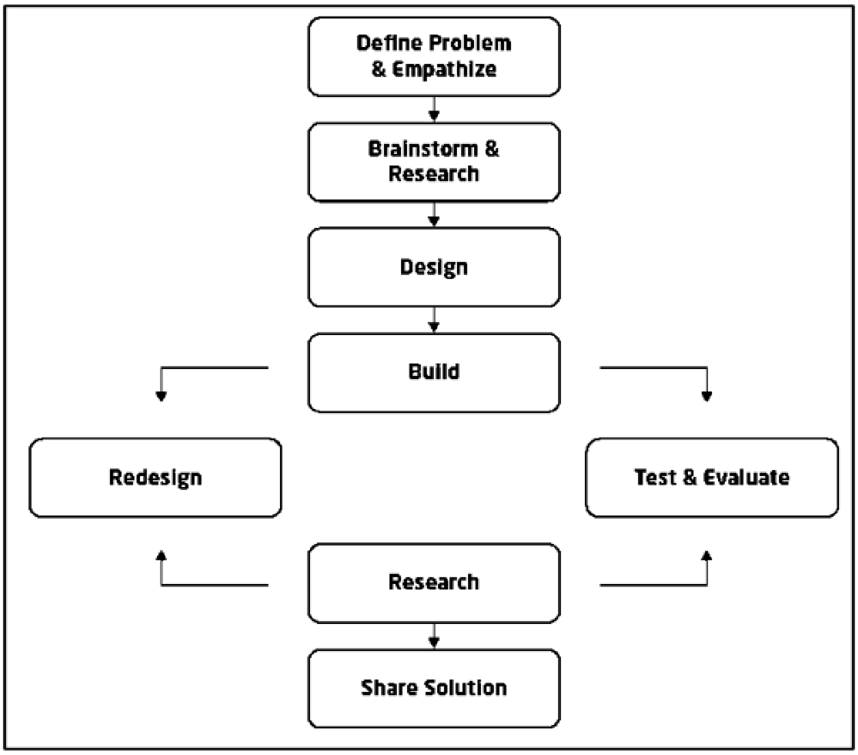

Fig. 2. Scheme of STEAM classes organization in America and many European countries (Lesseig *et al.*, 2017).

STEAM Education, as well as its development and application, is a critical component of the Azerbaijani educational system. As a result, on February 2, 2021, the President of Azerbaijan signed an order endorsing the document "Azerbaijan 2030: national socioeconomic development targets." One of the five national objectives for the country's socioeconomic progress over the next decade, according to this document, is to achieve "competitive human capital and a place for new ideas." This also made a significant contribution to the "STEAM Azerbaijan" project (Dashdemirov & Sharifov, 2019).

In the 2020/2021 academic year, the Ministry of Education launched the STEAM program in Baku's 6,000 public educational institutions, enrolling more than 6-grade students in 42 schools. The Ministry of Education provided the general education institutions where the program was implemented with the necessary training equipment and inventory. As a result, the Ministry of Education sent two groups of 100 teachers to

Israel to be trained as STEAM teachers from March 1 to 31 and November 17 to December 10, 2019. Furthermore, 34 teachers from 104 schools will receive professional staff training to deliver STEAM instruction between September 2 and 14, 2020.

We can conclude from the foregoing that papers on the organization of STEAM lessons in Azerbaijani schools are of poor quality. In this regard, pedagogical research on the establishment of STEAM lessons in Azerbaijan is required.

This article discusses the challenges and solutions to STEAM instruction in grades 6 through 8.

2. Material and methods

Employees from Azerbaijan State Pedagogical University's STEAM center and Physics Faculty conducted a survey on STEAM education in secondary schools. The survey was conducted at secondary schools No. 23, 114, and 251, as well as the Taraggi Lyceum. The survey included four school administrators, 23 STEAM teachers (22 female teachers and 1 male teacher), and 505 students (257 girls and 248 men). Two physics teachers, four biology teachers, one mathematics teacher, four mathematics-informatics teachers, nine informatics teachers, one art teacher, and two technology teachers are among the 23 STEAM teachers.

The school, according to school officials, was outfitted with the necessary equipment and gadgets, and their STEAM teachers received certification as a result of their participation in the program. The main disadvantage in most schools is that computers are not scaled to the number of students, and some devices and equipment remain unavailable. The absence of internet access in the rooms is the most serious concern. It is difficult to teach this subject due to the lack of a STEAM textbook that covers the pedagogical aspects in depth. The majority of STEAM educators use a single supplied program to train their students. Furthermore, the primary challenge of STEAM education is a lack of equipment. The STEAM science laboratories are used by the vast majority of teachers. 3D printers are becoming increasingly popular. Snapmaker is used by half of the teachers. Teachers who took part in the survey justified their decision by citing a lack of time and resources not covered in the accompanying class program. Tinkercad is used by almost all teachers. According to the survey results, the most difficult aspect of teaching STEAM programs is a lack of resources (internet, computer corresponding to students, textbooks, etc.). They almost certainly have a shortfall. Teachers appreciate being given resources.

In the survey, the students were asked the following questions:

1. Do you like the STEAM lesson?
2. Do you use the STEAM Lab?
3. Do you use a 3D printer in STEAM lessons?
4. Do your use the Snapmaker program in STEAM lessons?
5. Do you use the Tinkercad program in STEAM lessons?
6. What do you learn during the STEAM lesson?
7. What did you prepare for the STEAM lesson?
8. Can you repeat what you learned in the STEAM lesson at home?
9. What is your favourite aspect of the STEAM lesson?
10. Who do you contact for support if you face difficulties in the STEAM lesson?
11. How is the STEAM lesson different from previous classes?
12. What characteristics, in your opinion, should a STEAM educator possess?

3. Results

STEAM education is a favorite subject among secondary school students, according to data from pedagogical experiments. As evidenced by their responses to the third and fourth questions in Table 1, students in grades 6-8 value STEAM classes and use STEAM laboratories.

Table 1. Classification of answers to question

Grade, Answer	3rd question		4th question		5th question		6th question		7th question		10th question	
	sum	sum (%)	sum	sum (%)	sum	sum (%)	sum	sum (%)	sum	sum (%)	sum	sum (%)
6, Yes	168	88,89%	126	66,67%	94	49,74%	27	14,29%	173	91,53%	140	74,07%
6, No	0	0,00%	34	17,99%	37	19,58%	59	31,22%	8	4,23%	0	0,00%
6, I do know	13	6,88%	7	3,70%	4	2,12%	15	7,94%	0	0,00%	3	1,59%
7, Yes	142	94,67%	98	65,33%	121	80,67%	64	42,67%	144	96,00%	115	76,67%
7, No	0	0,00%	37	24,67%	14	9,33%	35	23,33%	4	2,67%	0	0,00%
7, I do know	8	5,33%	13	8,67%	1	0,67%	13	8,67%	0	0,00%	3	2,00%
8, Yes	149	89,76%	91	54,82%	127	76,51%	130	78,31%	157	94,58%	116	69,88%
8, No	3	1,81%	44	26,51%	3	1,81%	7	4,22%	1	0,60%	0	0,00%
8, I do know	9	5,42%	6	3,61%	0	0,00%	4	2,41%	1	0,60%	0	0,00%

Table 2. Classification of answers to question number 8 by class and gender

8th question		
Grade, Answer	**Sum**	**Sum (%)**
6, Learning science	26	13,76%
6, We study science, we make a model	63	33,33%
6, We make a model	62	32,80%
6, We prepare the project	14	7,41%
6, We make a project, make a model	49	25,93%
6, We study science, we develop a project	8	4,23%
6, We do nothing	0	0,00%
7, Learning science	29	19,33%
7, We learn science, we make a model	75	50,00%
7, We make a model	13	8,67%
7, We prepare the project	10	6,67%
7, We make a project, we make a model	79	52,67%
7, We study science, we develop a project	5	3,33%
7, We do nothing	0	0,00%
8, Learning science	14	8,43%
8, We learn science, we make a model	54	32,53%
8, We make a model	39	23,49%
8, We prepare the project	15	9,04%
8, We make a project, we make a model	63	37,95%
8, We study science, we develop a project	3	1,81%
8, We do nothing	7	4,22%

Table 3. Classification of answers to question number 11 by class and gender

11st question		
Grade, Answer	**Sum**	**Sum (%)**
6, To see the project work	141	74,60%
6, Listen to the teacher	22	11,64%
6, Both	0	0,00%
7, To see the project work	110	73,33%
7, Listen to the teacher	27	18,00%
7, Both	2	1,33%
8, To see the project work	108	65,06%
8, Listen to the teacher	32	19,28%
8, Both	0	0,00%

Table 4. Classification of answers to question number 12 by class and gender

12nd question		
Grade, Answer	**Sum**	**Sum (%)**
6, From the teacher	153	80,95%
6, Students	17	8,99%
6, Other	0	0,00%
7, From the teacher	131	87,33%
7, Students	7	4,67%
7, Other	2	1,33%
8, From the teacher	134	80,72%
8, Students	18	10,84%
8, Other	1	0,60%

Table 5. Classification of answers to question number 14 by class and gender

14th question		
Grade, Answer	**Sum**	**Sum (%)**
6, Creative	156	82,54%
6, Innovator	68	35,98%
6, Who is able to work with technology	123	65,08%
6, Educated	84	44,44%
6, World view	57	30,16%
6, Constantly working on their own	28	14,81%
7, Creative	129	86,00%
7, Innovator	52	34,67%
7, Who is able to work with technology	117	78,00%
7, Educated	52	34,67%
7, World view	38	25,33%
7, Constantly working on their own	61	40,67%
8, Creative	116	69,88%
8, Innovator	81	48,80%
8, Who is able to work with technology	96	57,83%
8, Educated	83	50,00%
8, World view	60	36,14%
8, Constantly working on their own	35	21,08%

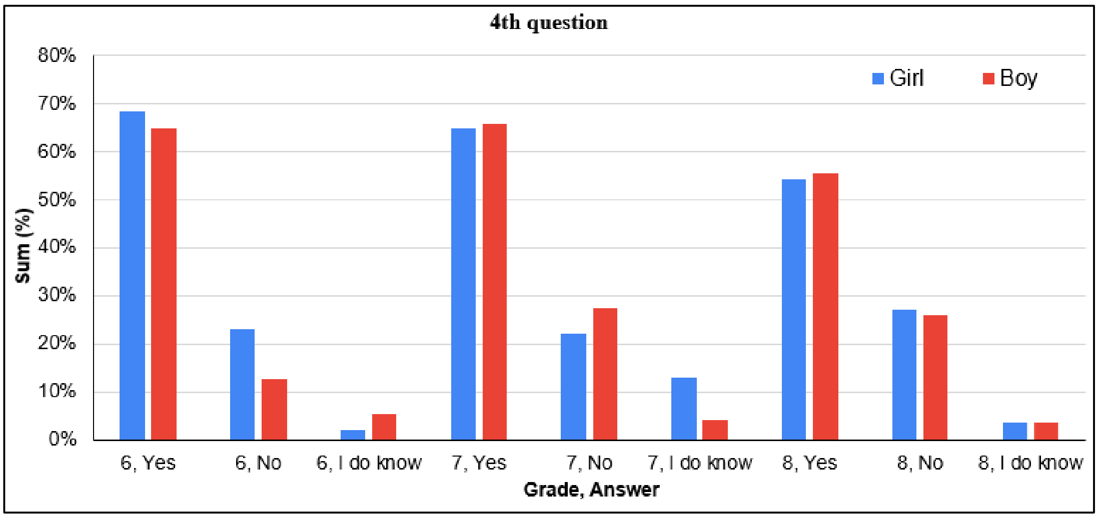

Fig. 3. Classification of answers to question number 4 by class and gender

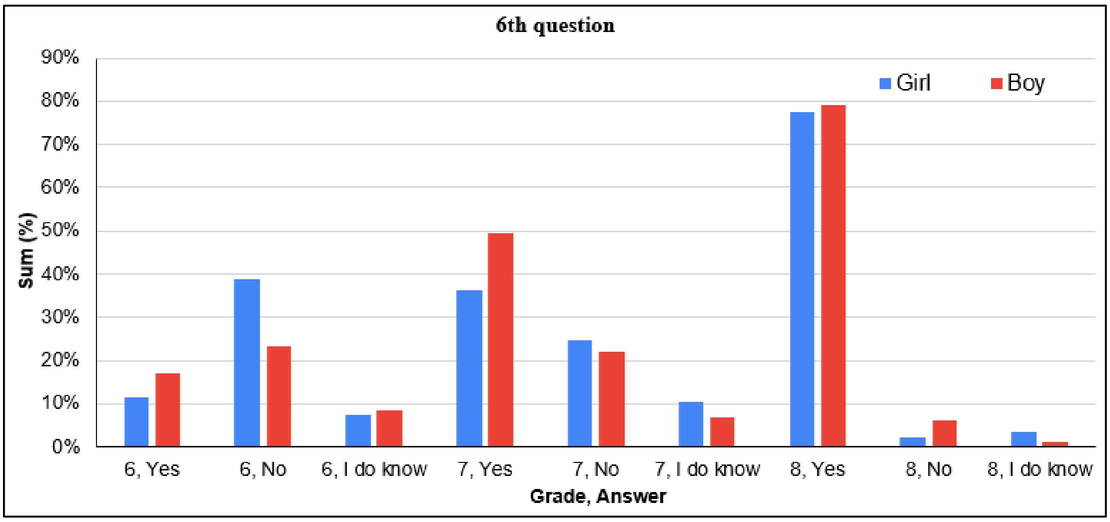

Fig. 4. Classification of answers to question number 6 by class and gender

However, approximately 20 to 25 percent of students do not use laboratories. Almost every student is aware of and familiar with 3D printers; additionally, the majority of eighth-grade students (80%) use Snapmaker. Students adore Tinkercard (Table 1) when it comes to determining what they want to accomplish during STEAM sessions; students in 7th grade, in particular, enjoy building models and completing projects (Table 2).

Table 3 shows that all students are capable of completing repeated assignments at home. However, approximately 20% of students in grades 7 and 8 choose to focus solely on the instructor throughout the class (Table 3). Furthermore, Table 4 shows that in the majority of cases, students seek guidance and assistance from professors. As a result, they want to see STEAM educators as creative and capable of collaborating with technology (Table 5).

Students who responded to survey question 9 stated that they typically prepared models of homes, robots, people, cups, bridges, and catapults as projects in STEAM lessons. Around 20%, on the other hand, stated that they were not taking any action. Naturally, this reaction implies that students do not engage in project work on purpose or in a systematic manner. In comparison to previous classes, students indicated on the 13th question of the survey that they enjoy working on projects, collaborating, and utilizing technology.

Figure 3 shows that the majority of grade VI females do not use STEAM Lab when responding to question 4. Females in Grade VI, on the other hand, were found to be less likely to use Snapmaker than males (Figure 4). This could also be due to the fact that the instructor in this class places less emphasis on collaborative work and prefers men to use technology.

4. Discussion

According to a student survey, children in the sixth and seventh grades are more interested in STEAM. STEAM Lab is mentioned by a few students. He noticed that many sixth-grade students were using the laboratory. This indicator is lower in grades 7 and 8 than it is in grades 6. He noticed that a growing number of seventh-graders now owned a 3D printer. Snapmaker is more commonly used in eighth grade, but it is rarely used in sixth and seventh grade. Tinkercad is widely used in all grades. More sixth and seventh graders apply what they learn in class at home. A sizable proportion of STEM students design layouts and projects. They specialize in the production of figurines, cups, ships, robots, catapults, automobiles, and bridges. Students enjoy completing assignments. If there are any problems during the lesson, they approach the teacher. In comparison to other disciplines, most students saw STEM as a pleasant, appealing, project-based topic that required much more than a computer. Most children believe that a STEAM teacher should be creative and knowledgeable about technology.

The following are the difficulties that have arisen as a result of empirical studies conducted in connection with STEAM teaching in schools in developed countries and Azerbaijan:

- Lack of information about pedagogical practice in STEAM Education;
- Implementation of the STEM lesson model requires some fundamental changes depending on the state of the learning environment;
- Teachers face difficulties when using new technologies, such as educational robots;
- Teachers' skills and expectations from STEAM lessons are optimistic;
- Teachers do not expect a particular share of household items, robotics, and a specific set of STEAM tools;
- Insufficient number of quality assessment tools;
- STEAM at the end of the lessons, the product is not analyzed from the point of view of some regions of science covering STEAM;
- Insufficient awareness of students about the essence of the STEM lesson;
- People who teach STEAM classes are experts in only one subject;
- Lack of a typical school structure, optimal student capacity in classrooms;
- Lack of systematic educational and methodological recommendations on STEAM;
- Lack of clear standards for STEAM discipline;
- Content of STEAM discipline projects;
- Time planning and Lack of time for STEM training;
- Lack of methodological recommendations on STEAM lessons for teachers;
- Unwillingness of teachers of the subject covering STEAM to cooperate;

– Low awareness of parents about STEAM;
– There is no systematic assessment and informing of pedagogical education in robotics.

Based on the above-mentioned challenges, it was proposed that a STEAM methodological guideline for teachers of sixth-eighth-grade students be developed, as well as the organization of targeted training for STEAM educators and the creation of a STEAM website to assist teachers and students in their efforts to learn more about pedagogical aspects of STEAM. Furthermore, STEAM lessons that follow to the strict teaching stages depicted in Figure 2 may be beneficial in acquiring the content of STEAM lessons based on Bloom's taxonomy.

5. Conclusions

This article focuses on students in grades 6-8 and their STEAM challenges, as well as potential solutions to those concerns. Various technical and pedagogical obstacles in the structure of STEAM programs have been identified through pedagogical surveys conducted at specific schools and lyceums. One of them is that, despite the completion of projects, STEAM classes do not provide evaluations of such projects in terms of science, technology, engineering, art, and mathematics. To resolve these issues, methodically structure the STEAM lesson, and resolve the difficulties that arise as a result, methods of methodological guidelines must be developed for the teacher and students.

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We would like to thank the principals of secondary schools 23, 114, 251, and Taraggi Lyceum for allowing us to conduct educational experiments. Furthermore, we applaud the staff of Azerbaijan State Pedagogical University's STEAM center and physics department for conducting surveys and questionnaires among students in secondary schools and lyceums.

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