

‘STEAM AT A DISTANCE’: A TEACHERS’ TRAINING SEMINAR IN STEAM EDUCATION

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ABSTRACT

This paper presents the development and implementation of a distance learning seminar for in-service teachers which focuses on STEAM Education. Participants were 321 in-service teachers of pre-primary and primary education who were working distantly. Towards this direction, a distance learning seminar on STEAM Education was designed. The main idea was to take advantage of distance learning facilities and create appropriate settings for in-service teachers in the domain of STEAM Education, providing activities and material that could be incorporated in their classrooms. Cultural Historical Activity Theory (CHAT) was used as a theoretical framework for the design and the analysis of the seminar. From the implementation of the seminar, quantitative and qualitative data was gathered. Data analysis so far has shown that in-service teachers participated in a series of learning actions that supported them to act as designers of formative interventions.

Keywords: STEAM Education, Cultural Historical Activity Theory (CHAT), Distance learning seminar

1.0 INTRODUCTION-THEORETICAL FRAMEWORK

In recent years, the European Union (EU) and other leading international organizations, including the United Nations (UN) and the Organization for Economic Cooperation and Development (OECD), have been making recommendations to all governments to review education systems, with emphasis mainly on the purpose and goals of education, the content and structure of educational programs and books as well as the teaching strategies and methods. Towards this direction, students are strengthened to become active citizens who will have a say in the contemporary global challenges and will actively participate in decision-making. To meet these challenges, it is important to develop educational curricula that support critical and creative thinking and cover successfully the needs of a diverse population of learners of the contemporary world. Traditional models of education, centred on memorization and standardized knowledge, do not address the complexity of modern life and are no longer enough to prepare students for it. This is where STEM education - Science, Technology, Engineering, and Mathematics - emerges as a transformative approach that equips learners with the tools needed for success in the 21st century citizens. (Plakitsi et al., 2018; European Commission, 2012; Next Generation Science Standards, 2013; OECD, 2022). The acronym

STEM originally appeared as ‘SMET’ in the United States in the 1990s. It was later reframed as STEM in 2001 by biologist Judith A. Ramaley, who, as Director of the U.S. National Science Foundation, played a key role in developing new curricula.

The National Science Foundation emphasized the particular importance of education so that each student can consolidate and learn the basic principles of STEM subjects and their connection, to become a literate citizen, thus ensuring a decent job in their adult life (Chesky & Wolfmeyer, 2015). In EU policymaking, the need to integrate new technologies into the education and training of workers has been included as an issue to be resolved with immediate priority. STEM, through an interdisciplinary approach, focuses on understanding and solving real-world problems. It is an educational approach that introduces Technologies and Engineering Science, as a means of human interaction with the universe, into the teaching of Mathematics and Natural Sciences, which are vital for the basic understanding of the universe in a blended learning environment that shows students how the scientific method can be applied to everyday life. STEM emphasizes authentic problem-solving, critical thinking, collaboration, and the use of the research process, yet effective implementation remains challenging, particularly for early childhood and primary educators who often lack sufficient STEM preparation. Growing evidence supports introducing STEM in early childhood, as early exposure helps children adapt to technological change, appreciate science as a human endeavour, and develop evidence-based problem-solving skills (Kalogiannakis & Ampartzaki, 2022).

STEAM education includes Art as an additional component that provides various possibilities for functional interdisciplinary connections between the four original pillars of STEM. Within this approach, emphasis is put on research, collaboration, the ability to creatively find solutions to a problem, and process-based learning (Rodrigues-Silva & Alsina, 2023). According to Yakman & Hyonyong (2012), the pillars of the STEAM methodology are interconnected, and each represents a distinct cognitive domain essential for holistic learning. Science encompasses everything that exists in the natural world, forming the basis for understanding natural phenomena. Technology refers to all human-made tools and systems designed to meet human needs through the purposeful transformation of natural materials. Engineering involves the systematic and methodical processes through which humans design, construct, and optimize manufactured products. Mathematics supports these domains by providing the numerical and symbolic language needed to represent, explain, and validate scientific, technological, and engineering processes. Finally, Art encompasses a wide range of humanistic and creative disciplines—including language, history, politics, theology, sociology, music, dance, ergonomics, psychology, and the fine arts—highlighting the cultural, expressive, and social dimensions that enrich and contextualize scientific and technical understanding. Collectively, these pillars illustrate the comprehensive and interdisciplinary nature of STEAM education.

Towards this direction, a distance learning seminar for in-service teachers on STEAM Education was designed. Cultural Historical Activity Theory (CHAT) was used as a theoretical framework for the design and the analysis of the seminar. CHAT supports the design of formative interventions that go beyond transmitting knowledge and involve an opening to society, links of knowledge with everyday life, as well as the development of competences connected with socio-scientific issues (Engeström, 2019). The unit of analysis is the activity which includes the person or group who is acting towards an object, following certain rules

and the dynamic relationships developed within the activity system (Barab et al, 2004; Lee, 2015). The seminar followed the basic parts of SCOPES (Systems of activity, Contradictions, Outcomes, Praxis, Expansive learning, Science education), a methodological tool for Science Education based on CHAT (authors, 2019). Within this frame, the activity systems and the common object were defined, contradictions were analysed, expected outcomes were reached through praxis, the expansive learning cycle was used for designing learning activities and Science Education was used as a starting point for STEAM Education.

In this study, the expansive learning approach was implemented in a micro-scale (Engeström, 2020) which emerges when a group of learners participate in an intensive problem-solving situation of a challenging issue. Participants attended an online seminar which addressed their need to teach STEAM activities in their classrooms. The role of conflicts in the form of contradictions was critical for the evolution of the activity systems of the instructors of the seminar, the school counsellors and the in-service teachers. Within this frame, STEAM activities were designed as collective activities that involve change and bring new practices within the learning community.

2.0 METHODOLOGY

2.1 The seminar

The distance learning seminar consisted of two parts, a theoretical one concerning the connection of STEAM Education and expansive learning and a practical in which two virtual STEAM labs were presented entitled 'Light as an entity in science and life' (Figure 1) and 'From magnetic toys to the wonders of Science' (Figure 2). Each lab consists of rooms connected with the pillars of STEAM; there are two rooms for each letter with online activities. With the aid of a comic character, Mr. STEAM (Figure 3), participants became acquainted with all the rooms of both labs and the relevant activities and discussed the prospect of using them in their own classrooms. At the end, participants designed a single activity concerning a science education topic connected with the rooms the virtual STEAM labs. Contemporary challenges of promoting a different kind of education came up, so the outcome of the seminar was to produce educational material which would inspire learners on the one hand and focus on developing skills, rather than simply following scientific facts-oriented education.



Figure 1: The virtual lab 'Light as an entity in science and life'

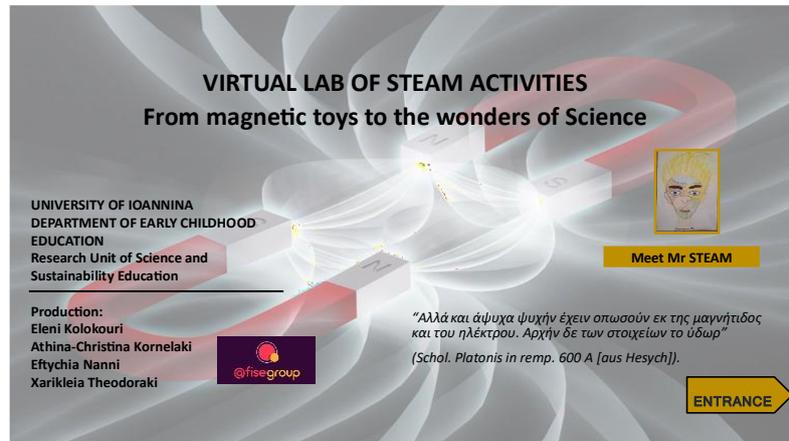


Figure 2: The virtual lab 'From magnetic toys to the wonders of Science'



Figure 3: Mr. STEAM

Quantitative and qualitative data was gathered from the implementation of the distance learning seminar. At the beginning, the in-service teachers answered an on-line anonymous questionnaire which concerned their views and their experience of STEAM Education as well as their willingness to use STEAM activities in their classrooms. At the end of the seminar participants followed a series of actions to design their own activities in an expansive learning cycle. The main idea was to take advantage of distance learning facilities and create appropriate settings for in-service teachers in the domain of STEAM Education. In this process there was a strong need to identify the germ cell, in other words the starting point from which in-service teachers would develop their skills in STEAM Education distantly. The research questions that came up were:

- What were the in-service teachers' views about STEAM education?
- What were the conflicts/contradictions during the distance learning seminar and how did they affect the activity systems?

Participants in this research were 321 in-service teachers working distantly. The vast majority of the teachers were Pre-primary school teachers (82.2%, 264 teachers) whereas Primary school teachers represented 14.0% of the sample (45 teachers) (Table 1).

Table 1: The sample of the research study

Levels	Counts	% of Total	Cumulative %
Pre-primary schoolteacher	264	82.2 %	82.2 %
Primary schoolteacher	45	14.0 %	96.3 %
Other	12	3.7 %	100.0 %

Teaching experience of the participants varied. The teaching experience of the majority of the sample was 11 and 30 years: 40.2% (129 participants) had teaching experience of 11-20 years whereas 40.8% (131 participants) had teaching experience of 21-30 years and 19.0% (61 participants) had teaching experience 1-10 years (Table 2).

Table 2: The teaching experience of the sample

Levels	Counts	% of Total	Cumulative %
1-10 years	61	19.0 %	19.0 %
11-20 years	129	40.2 %	59.2 %
21-30 years	131	40.8 %	100.0 %

3.0 RESULTS

The data collected were analysed through SPSS (v26). The following questions refer to STEAM education and more precisely to the participants' views on and familiarity with STEAM approach, as well as the conflicts/contradictions that came up during the distance learning seminar.

The first question concerned teachers' familiarity with STEAM and response choices included: 1: Not at all familiar, 2: Slightly familiar, 3. Somewhat familiar, 4: Moderately familiar, 5: Extremely familiar. With a mean value of 2.67 (SD: 1.15) we can conclude that participants were somewhere between Slightly and Somewhat familiar with the STEAM approach before attending the educational seminar. Frequencies are as depicted below: (Table 3)

Table 3: Teachers' familiarity with STEAM

Levels	Counts	% of Total	Cumulative %
Not at all familiar	52	16.2 %	16.2 %
Slightly familiar	101	31.5 %	47.7 %
Somewhat familiar	94	29.3 %	76.9 %
Moderately familiar	49	15.3 %	92.2 %
Extremely familiar	25	7.8 %	100.0 %

Then, the participant teachers were asked where they first learned about STEAM. Most teachers (41.9%, 134) said that they first learned about STEAM from Other Seminars/Other

Trainings while 19.4% (62 participants) said that they first learned about it from the Internet/Social Networks. STEAM was part of their education at University/ Studies for the 10.0% (32 participants) of the sample while 8.8% first learned about STEAM from Articles, books or Papers. Lastly, 9.7% (31 participants) had never heard about STEAM education before as shown in Table 4.

Table 4: Origin of Teachers’ STEAM knowledge

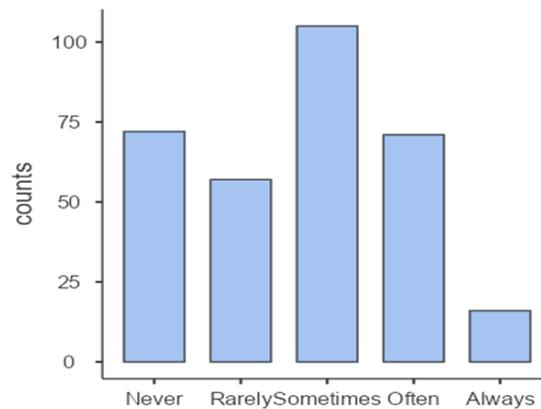
Levels	Counts	% of Total	Cumulative %
Articles/ Books/ Papers	28	8.8%	8.8%
Other Seminars/ Other trainings	134	41.9%	50.6%
University/ Studies	32	10.0%	60.6%
Never heard of STEAM	31	9.7%	70.3%
Internet/ Social Networks	62	19.4%	89.7%
Colleagues	33	10.3%	100.0%

Teachers’ opinion about the STEAM approach was assessed in a closed – ended question with the response choices including: 1: Very Negative, 2: Negative, 3: Neutral, 4: Positive, 5: Very positive. With a mean value of 4.12 (SD: 0,78) the sample seems to have a positive opinion about the STEAM approach, as shown below (Table 5). Moreover, the absence of Very Negative opinions, and the relatively small frequency of Negative opinion (2%) about STEAM approach ascertains the overall positive opinion about STEAM education of the in-service teachers.

Table 5: Teachers’ opinion about the STEAM approach

Levels	Counts	% of Total	Cumulative %
Very negative	1	0.3%	0.3%
Negative	5	1.6%	1.9%
Neutral	60	18.7%	20.6%
Positive	145	45.2%	65.7%
Very Positive	110	34.3%	100.0%

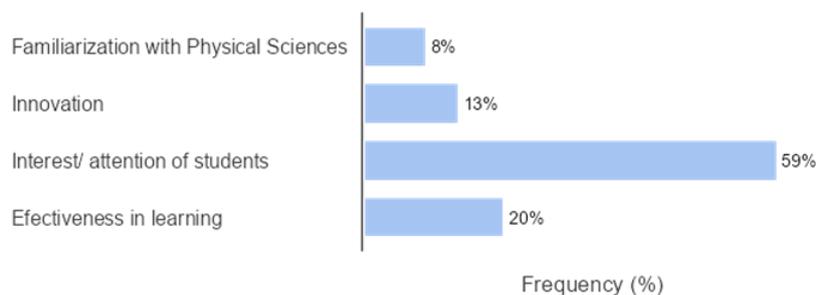
The use of STEAM approach in teachers’ teaching was assessed subsequently with a closed-ended question. Response choices included: 1: Never, 2: Rarely, 3: Sometimes, 4: Often, 5 Always. With a mean value of 2.69 (SD: 1,19) we can conclude that STEAM approach was rarely to sometimes used by the teachers. Frequencies are depicted in the following graph (Graph1). The majority of the sample seems to be using STEAM approach Sometimes (32.4%, 105 participants), while educators that Never use STEAM approach rise up to 22.4% (72 participants). On the other hand, educators that Often and Always use the STEAM approach while teaching hold the 22.1% (71 participants) and 5.0% (16 participants) respectively.



Graph 1: The use of STEAM approach

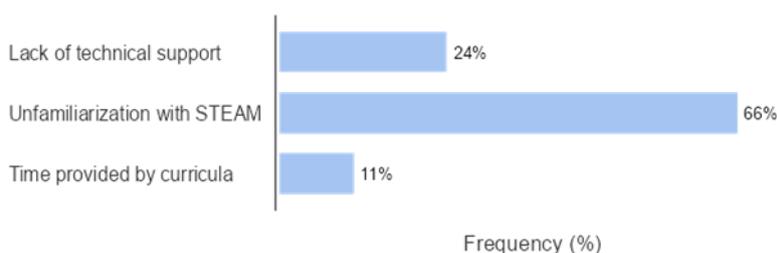
The points that encouraged or discouraged teachers from using the STEAM approach while teaching are as depicted in the following graphs (Graph 2 & 3). Teachers were mostly encouraged in using STEAM approach while teaching according to the Interest/ Attention of students. More specifically, students seemed to be interested in everything that has to do with STEAM approach showing continuous attention and motivation to participate in the education process. Moreover, the STEAM approach seems to have a positive effect in learning while innovation and familiarization with Natural Sciences seem to be points that encourage them in using it. On the other hand, teachers seem to be discouraged by the unfamiliarity with STEAM, while Time provided by curricula and Lack of technical support are points that play a significant role in using STEAM approach in teaching.

What is the point that encourages you to use the STEAM approach in your teaching?



Graph 2: Points that encourage the use of STEAM approach

What is the point that discourages you from using the STEAM approach in your teaching?



Graph 3: Points that discourage the use of STEAM approach

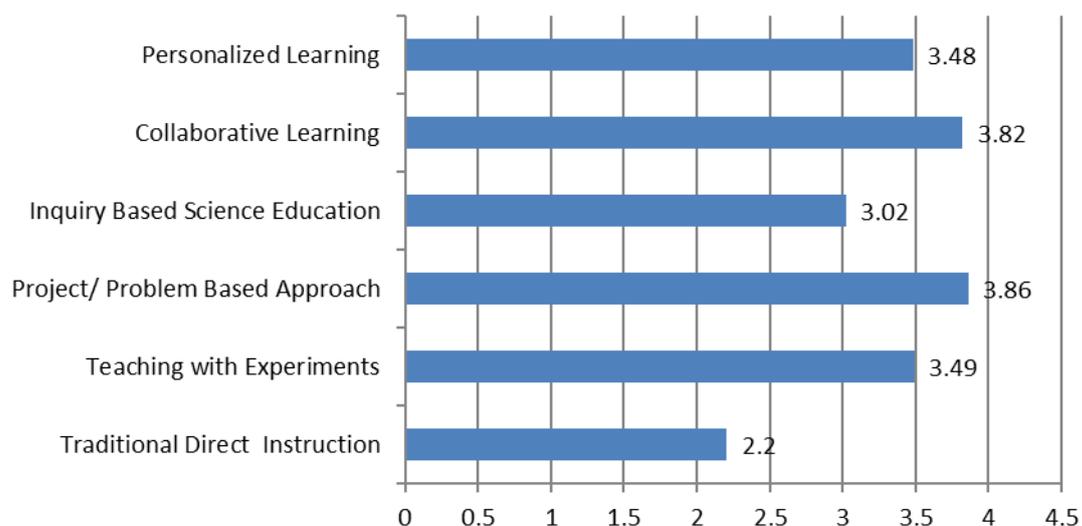
As a next step, teachers were asked to rate which pedagogical approaches they were using in their STEAM teaching, while response choices included: 1: Never, 2: Rarely, 3: Sometimes, 4: Often, 5: Always. In order to obtain comparative vision of the approaches, a mean value was calculated for each one, as depicted in the following table (Table 6).

Table 6: Pedagogical Approaches used in STEAM teaching

	Mean	SD
Traditional Direct Instruction	2.20	1.096
Teaching with Experiments	3.49	0.891
Project/ Problem Based Approach	3.86	0.939
Inquiry Based Science Education	3.02	1.052
Collaborative Learning	3.82	0.859
Personalized Learning	3.48	0.949

Note: 1: Never; 2: Rarely; 3: Sometimes, 4: Often, 5 Always

With a mean value of 3.86 (SD: 0.939), we can conclude that the pedagogical approach that is most used in STEAM teaching is Project Based Science Education followed by Collaborative Learning with a mean value of 3.82 (SD: 0.859). Both approaches seem to be Often used in STEAM teaching. Personalized Learning and Teaching with Experiments seem to be used in STEAM teaching between Sometimes and Often whereas Traditional Direct Instruction seem to be Rarely used in STEAM teaching. The comparative average use of pedagogical approaches in STEAM teaching is depicted to the graph below (Graph 4):



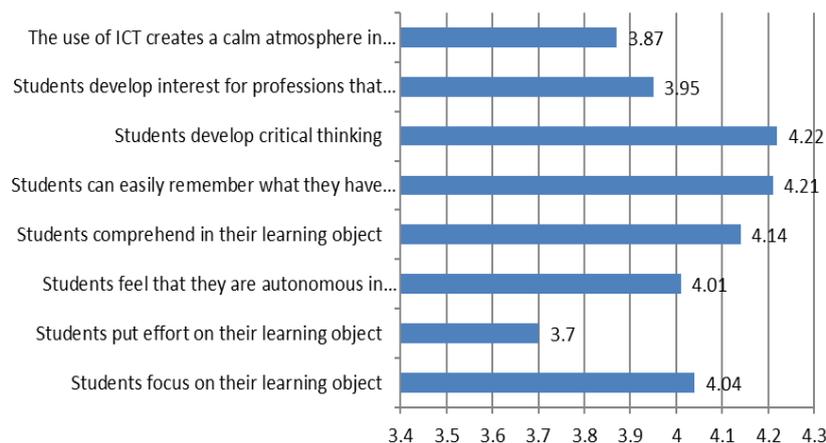
Graph 4: The comparative average use of pedagogical approaches in STEAM teaching

The positive impact of the STEAM approach on various educational fields, was assessed in the relevant question, while the response choices included: 1: Never, 2: Rarely, 3: Sometimes, 4: Often, 5: Always. Mean values and Standard deviation are as depicted below (Table 7).

Table 7: The positive impact of the STEAM approach

	Mean	SD
Students focus on their learning object	4.04	0.669
Students put effort on their learning object	3.70	0.897
Students feel that they are autonomous in their learning	4.01	0.742
Students comprehend in their learning object	4.14	0.666
Students can easily remember what they have learnt	4.21	0.687
Students develop critical thinking	4.22	0.726
Students develop interest for professions that involve STEM activities	3.95	0.791
The use of ICT creates a calm atmosphere in the classroom	3.87	0.835

From the above table we can conclude that STEAM education seems to have Often a positive impact to all the assessed fields. More specifically STEAM approach has a positive impact on the development of students’ critical thinking (M: 4.22, SD: 0.726) while students can easily remember what they have learned (M: 4.21, SD: 0.687). Students putting effort into their learning object is the least often affected field that STEAM has a positive impact on (M: 3.70, SD: 0.897). The comparative positive impact of STEAM approach is depicted to the graph below (Graph 5).



Graph 5: The comparative positive impact of STEAM approach

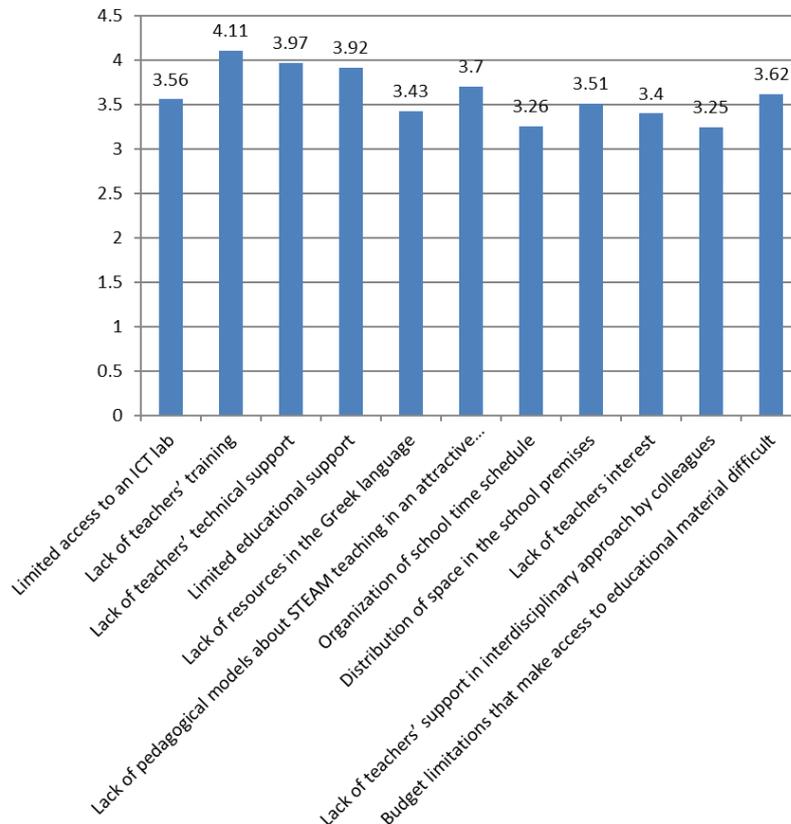
Furthermore, the factors that affected STEAM teaching were assessed with a closed-end question. Response choices included: 1: Never, 2: Rarely, 3: Sometimes, 4: Often, 5: Always, while mean values and standard deviations are shown below (Table 8).

Table 8: The factors that affect STEAM teaching

	Mean	SD
Limited access to an ICT lab	3.56	1.020
Lack of teachers' training	4.11	0.843
Lack of teachers' technical support	3.97	0.906
Limited educational support	3.92	0.879
Lack of resources in the Greek language	3.43	1.004
Lack of pedagogical models about STEAM teaching in an attractive way	3.70	0.908
Organization of school time schedule	3.26	1.088
Distribution of space in the school premises	3.51	1.046
Lack of teachers interest	3.40	1.117
Lack of teachers' support in interdisciplinary approach by colleagues	3.25	1.034
Budget limitations that make access to educational material difficult	3.62	1.024

Note: 1: Never; 2: Rarely; 3: Sometimes, 4: Often, 5 Always

We can conclude that with a mean value of 4.11 (SD: 0.843) Lack of teachers training often affects the use of STEAM. Moreover, Lack of teachers' technical support and Limited educational support seem to both affect the use of STEAM, with respective mean values rising to 3.97 (SD: 0.906) and 3.92 (SD: 0.879). The field that least affected the use of STEAM education appeared to be the Lack of teachers' technical support in interdisciplinary approach by colleagues, with a mean value of 3.25 (SD: 1.034) (Graph 6).



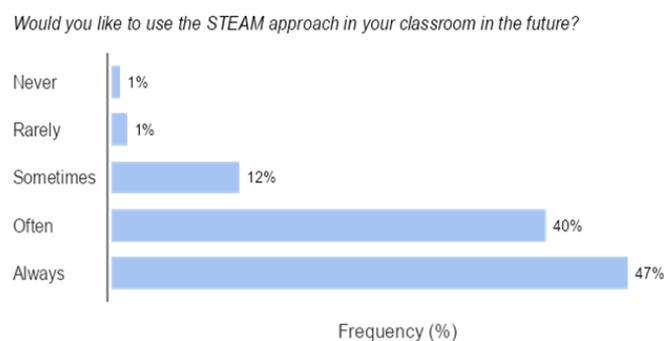
Graph 6: The factors that affect STEAM teaching

Lastly, teachers were assessed in a closed-end question about their intention to use the STEAM approach in their classroom, while the response choices included: 1: Never; 2: Rarely; 3: Sometimes, 4: Often, 5 Always. With a mean value of 4.31 (SD: 0.772) we can conclude that educators intend to Often use the STEAM approach in their classroom in the future. The frequencies and relative frequencies are depicted in the table (Table 9) and the graph below (Graph 7).

Table 9: Intention to use STEAM in the classroom

Levels	Counts	% of Total	Cumulative %
Never	2	0.6 %	0.6 %
Rarely	4	1.2 %	1.9 %
Sometimes	37	11.5 %	13.4 %
Often	127	39.6 %	53.0 %
Always	151	47.0 %	100.0 %

The majority of the sample intends to Always use the STEAM approach in their classroom (47.0%, 151 educators) while 39.6% (127 educators) intend to Often use the STEAM approach in their classroom. Educators that intend to Often use in rise to 11.5% (37 educators) while the ones that intend Rarely or Never use the approach are the 1.2% (4 educators) and 0.6% (2 educators) respectively.



Graph 7: Intention to use STEAM in the classroom

The contradictions that emerged in the form of conflicts during the implementation of the distance learning seminar were seen in diverse forms such as frustrations, tensions, difficulties and contradictory opinions. The contradictions related to the issue of individual and team responsibilities affected teachers’ participation in the seminar. The different teaching ideas, methods and practices and the lack of teachers’ training caused a certain degree of anxiety concerning the use of STEAM in their classrooms. The contradictions that emerged during the implementation of the seminar were related to the four levels of contradictions, developed by Engeström, are shown in the table below (Table 10). According to Engeström (1987), there is a need state that causes contradictions-changes within the activity system. These contradictions lead to the expansion and evolution of the activity system. In this frame, the study of contradictions provides the field to make connections with the teachers’ personal experience and their own needs as educators. As a next step, learning can be expanded in the wider

community and include social organisations and policy makers which affect in various ways the course of their profession.

Table 10: Contradiction analysis

Contradiction Level	Engeström’s definition	Observations and findings of analysis from this study
<i>Primary Contradiction</i>	“...the inner conflict between exchange value and use value within each corner of the triangle of activity.”	Individuals, teachers, teacher trainers and teachers’ groups do not share a common value system on how to connect the goals of sustainable development with science curricula and Inclusive Education.
<i>Secondary Contradiction</i>	“...are those appearing between the corners. The stiff hierarchical division of labor lagging behind and preventing the possibilities opened by advanced instruments is a typical example.”	-
<i>Tertiary Contradiction</i>	“...appears when representatives of culture (e.g., teachers) introduce the object and motive of a culturally more advanced form of the central activity into the dominant form of the central activity.	New teaching methods and suggested teaching ideas within the frame of Laboratory Skills imposed by not necessarily fit into teachers’ daily classroom practices.
<i>Quaternary Contradiction</i>	“...require that we take into consideration the essential 'neighbour activities' linked with the central activity which is the original object of our study.”	Teachers’ daily classroom practices interact with other ‘neighbour activities’ and therefore the implementation of these practices requires more changes.

5.0 CONCLUSIONS AND DISCUSSION

The purpose of this study was to examine in-service teachers’ perceptions of STEAM education and explore the contradictions that emerged during a distance-learning STEAM seminar based on Cultural-Historical Activity Theory (CHAT). The findings illustrate that teachers entered the seminar with limited familiarity but highly positive attitudes toward STEAM. The analysis of results showed that most teachers possessed only basic awareness of the approach, which aligns with international studies indicating insufficient STEAM preparation in both pre-service and in-service teacher training (Margot & Kettler, 2019).

Teachers demonstrated a clear interest in STEAM and recognized its value in enhancing student engagement, critical thinking, and meaningful learning. They also expressed strong intentions to incorporate STEAM in their classrooms. However, their limited prior familiarity with the approach, combined with structural challenges such as insufficient training, limited time, and inadequate technical support, remains a significant barrier. Towards this direction, pedagogical change requires structured professional development and opportunities for collective reflection (Henriksen, 2014; Martins & Baptista, 2024; Yakman & Hyonyong, 2012).

The CHAT framework analysis revealed that contradictions within and between activity systems are central to understanding teachers' experiences. These contradictions provided productive opportunities for reflection, dialogue, and the development of new pedagogical practices. The virtual STEAM labs, together with the collaborative design activities, offered teachers accessible ways to experiment with interdisciplinary approaches and to envision new forms of teaching that connect science, technology, engineering, arts, and mathematics. In conclusion, the seminar demonstrated that distance learning environments, when grounded in strong theoretical frameworks and supported by well-designed activities, can effectively contribute to teacher professional development in STEAM education. Future initiatives should include more practical training, and opportunities for collaborative design to sustain teachers' capacity to integrate STEAM meaningfully into their classrooms.

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