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Publicação Contínua

Effects of a practical teacher-training program on STEAM activity planning

Efeitos de um programa prático de formação de professores em planejamento de atividades STEAM

Efectos de un programa práctico de formación del profesorado en la planificación de actividades STEAM

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Abstract: We sought to analyse the effects of a practical teacher-training program on teachers' abilities in planning STEAM activities. For that, a case study is presented in a mixed-method research approach. 14 Brazilian teachers took part in a course wherein they received mentoring, instruments, and feedback to develop STEAM plans. In this research, data were collected from two surveys, from previously validated open-ended questions, and from the STEAM plans as final products. Quantitative data was analysed through nonparametric statistical tests, and qualitative data underwent content analysis according to the Ground Theory commandments. As a result, teachers reported a positive view of the STEAM impact and a high predisposition towards it. Although they considered merging STEAM areas challenging, especially Engineering and Technology, the training helped them surpass it. All plans had at least two areas, and half of them had all five STEAM areas. Around 70% of the teachers used an active learning teaching method which was new to them. There was a significant augment in teachers' self-efficacy in planning STEAM activities.

Keywords: Lesson planning, STEAM Education, Teacher professional development.

Resumo: Analisaram-se os efeitos de um programa prático de formação docente no desenvolvimento de habilidades dos professores no planejamento de atividades STEAM. Para isso, apresenta-se um estudo de caso com uma abordagem de pesquisa de métodos mistos. 14 professores brasileiros participaram de um curso no qual receberam mentoria, ferramentas e feedback para desenvolver planos didáticos STEAM. Nesta pesquisa, foram coletados dados por meio de questionarios, de perguntas abertas previamente validadas, e os planos STEAM como produtos finais. Os dados quantitativos foram analisados por meio de testes estatísticos não paramétricos e os dados qualitativos foram submetidos à análise de conteúdo de acordo com indicações da Teoria fundamentada. Como resultado, os professores relataram uma visão positiva sobre impacto de STEAM e uma alta predisposição em deenvolvê-lo. Apesar de considerarem integrar as áreas STEAM uma tarefa desafiadora, especialmente Engenharia e Tecnologia, o treinamento os ajudou a enfrentá-la. Todos os planejamentos tinham pelo menos duas áreas, e metade deles tinha todas as cinco áreas STEAM. Cerca de 70% dos professores utilizaram um método de ensino de aprendizagem ativa que era novo para eles. Houve um aumento significativo na autoeficácia dos professores no planejamento de atividades STEAM.

Palavras-chave: Desenvolvimento professional docente, Educação STEAM, Planejamento didático.

Resumen: Se analizan los efectos de un programa práctico de formación docente sobre el desarrollo de las habilidades del profesorado en la planificación de actividades STEAM. Para ello, se presenta un estudio de caso con un enfoque de investigación de método mixto. 14 profesores brasileños participaron de un curso en el cual recibieron mentoría, instrumentos y retroalimentación para desarrollar planes STEAM. En esta investigación se recolectaron datos de dos encuestas, de preguntas abiertas previamente validadas, y de los planes STEAM como productos finales. Los datos cuantitativos fueron analizados a través de pruebas estadísticas no paramétricas, y los datos cualitativos fueron sometidos a análisis de contenido de acuerdo con las indicaciones de la Teoría Fundamentada. Como resultado, los docentes informaron una visión positiva del impacto STEAM y una alta predisposición hacia ello. Si bien consideraron desafiante fusionar áreas STEAM, especialmente Ingeniería y Tecnología, la capacitación les ayudó a enfrentar esta dificultad. Todos los planes tenían al menos dos áreas, y la mitad de ellos tenían las cinco áreas STEAM. Alrededor del 70% de los profesores utilizaban un método de enseñanza de aprendizaje activo que era nuevo para ellos. Hubo un aumento significativo en la autoeficacia de los docentes en la planificación de actividades STEAM.

Palabras clave: Desarrollo professional docente, Educación STEAM, Planificación didactica.

INTRODUCTION

STEAM is an educational approach which argues for interdisciplinarity between Science, Technology, Engineering, Arts/ Humanities, and Mathematics. This acronym emerged during the Americans for the Arts-National Policy Roundtable discussion in 2007 (Perignat & Katz-Buonincontro, 2019). Since then we observe excitement (Cook et al., 2020) and uninterrupted research about it (Getmanskaya, 2021; Marín-Marín et al., 2021). STEAM's main justification lies in the argument that, in a highly technological world, complex problems cannot be addressed by isolated knowledge (López et al., 2021; Quigley et al., 2017).

Most studies on STEAM are focused on students, curriculum, and assessment (Kartini & Widodo, 2020), whereas little research addresses STEAM teaching training programs (Kim & Bolger, 2017). Accordingly, a bibliometric analysis of performance and co-words in Web of Science confirms this gap. Findings showed teacher training is a recent thread on STEAM. And this research line became evident only from 2019 (Marín-Marín et al., 2021).

Besides being a new thread, researchers agree on the necessity of proper teacher training to ensure STEAM implementation in schools (Cook et al., 2020). In addition, studies suggest teachers without solid content knowledge and pedagogical skills associated with STEAM are likely to experience pedagogical discontentment during the attempt to implement it (Boice et al., 2021).

Some already existing research emerges on teachers' difficulties and needs for STEAM implementation. They also struggle to merge STEAM areas beyond simply adding those components together (Cook et al., 2020). For instance, Boice et al. (2021) observed teachers tend to teach content from their specific discipline, while only superficially contextualising its relation with other areas. Teachers are likely to focus on activities, neglect content knowledge, and plan assessments on performance or final products rather than evaluating the learning process (Cook et al., 2020). Furthermore, they lack familiarity with Engineering (Webb & LoFaro, 2020) and they are likely to reduce Technology from a proper knowledge area to the mere use of resources, such as digital devices (Cook et al., 2020).

Moreover, there is a significant mismatch between teachers' perceptions and actual practices of STEAM education (Park et al., 2016). Studies show teachers usually have a positive view and apparent support for STEAM (Kartini & Widodo, 2020; Park et al., 2016), although many of them actually resist implementing it in their classes (Park et al., 2016). Teachers have opinions and perhaps misconceptions about STEAM (Kartini & Widodo, 2020; Lee, 2021; Park et al., 2016), and those beliefs have a great influence on their teaching.

This panorama, where teachers may have misconceptions and struggle with implementing STEAM, encourages the search for an appropriate educational approach to teacher training on STEAM Education.

The literature already has a clue in this sense. Researchers found teachers prefer STEAM teacher training with practical features, such as case-centred, activity-centred, and field applications methods (Leroy & Romero, 2021). Accordingly, practical teacher training programs focused on STEAM planning have shown promising results (Boice et al., 2021; Cook et al., 2020; Kim & Bolger, 2017). It responds to teachers' needs since planning STEAM is challenging for them (Boice et al., 2021; Cook et al., 2020).

Cook et al. (2020), for example, reported a two-year practical teacher-training program on STEAM activity planning. Their results showed an increase in the alignment of the plans with quality standards, meaningful integration of STEAM knowledge areas, and use of formative assessment. After one year of training, Boice et al. (2021) observed teachers unanimously reported using STEAM in their classes at least sometimes.

Considering all that, a four-month practical teacher-training program on STEAM activity planning was enrolled in Brazil. During this formation, teachers shared their prior knowledge and beliefs about STEAM. Then, they received guidelines and templates for planning STEAM activities. In parallel, lessons and mentoring intended theoretical scaffolding on STEAM and active learning teaching methods. After two feedback sessions from the mentor teacher over their STEAM planning. Finally, teachers underwent peer and self-assessment processes using a rubric to verify STEAM plans alignment. The course ended with a reflection session about their learning.

Addressing the stated literature gap on STEAM teacher training, the following research questions are formulated:

RQ1. What are teachers' initial opinions related to STEAM Education?

RQ2. How did the teacher training program affect teachers' abilities on planning STEAM activities?

Responding to those questions, this research aims to analyze the effects of a practical teacher-training program on teachers' abilities in planning STEAM activities.

METHODOLOGY

The research has a mixed-method approach (Mcmillan & Schumacher, 2005). It is a case study about an online practical teacher-training program STEAM activity planning. This course was enrolled from May to August 2021 (four months duration) at the Federal Institute of Minas Gerais (IFMG), in Brazil. As previously indicated in the introduction, during this training teachers shared and discussed their beliefs about STEAM. Then, they received mentoring and instruments for planning STEAM activities. Table 1 details the four stages of the program and its corresponding processes.

Table 1

Stages and processes of the teacher-training program on planning STEAM activities

Month/year	Stage	Process
May/2021	Welcoming and preparation	Personal presentation Organization: guidelines, deadlines, templatesDiscussions on prior knowledge and beliefs about STEAM Theoretical scaffolding on STEAM and active learning methods
June/2021	Feedback – first round	Feedback centred on issues related to STEAM, teaching methods, learning objectives
July/2021	Feedback – second round	Feedback centred on issues related to STEAM planning (timing, assessment, etc.), and text body structure
August/2021	Finalization	Peer and self-assessment Final versionReflection on learning

20 teachers freely took part in the mentioned teacher training program, 14 of whom volunteered to be included in this research. Those teachers firmed a consent term. We highlight most teachers are from Humanities (10), some from science (3) and also from engineering (1). Additionally, there was a non-equilibrated gender distribution, with 11 female and 3 male participants. From now on, participants are simply referred to as teachers, and whenever necessary, we will code them as P01 until P14 for anonymity purposes.

Data was collected from different sources. At the beginning of the program, participants filled out a form regarding sample characterization (such information was already presented above). Simultaneously, we administered survey I, a Likert instrument (scale 1 to 5) organized into two main parts. Teachers' evaluation of 18 educational approaches was explored considering four dimensions: Knowledge, Usage, Willing to use, and Appropriateness to STEAM (part A). Teachers' opinions on STEAM Education impact, predisposition toward STEAM, self-efficacy in considering each STEAM area, and the general self-efficacy in planning STEAM activities (part B).

At the end of the program, the STEAM activity plans were collected as teachers' final product. Additionally, we administered survey II. This instrument was also organized into two parts: general self-efficacy in planning STEAM activities was repeated (part A). Open-ended questions about planning STEAM activities, from a more qualitative perspective (part B). Those open-ended questions were previously validated by Kim and Bolger (2017) during an investigation of a teacher training program on STEAM planning enrolled in Korea. In Table 2 we present a summary of data sources, themes, the quantity of questions/elements, and the analyses procedure.

Table 2

Data source and analysis

Data source		Theme	Quantity of questions/elements	Analysis
Form		Sample characterization	4 questions	Descriptive statistics
Survey I	Part A	Educational approaches	18 educational approaches x 4 dimensions	One way within-subject ANOVA Likert graphical representation Wilcoxon Signed Ranks test
	Part B	STEAM Education impact	15 elements	Descriptive statistics: percentile and Friedman test
		Predisposition towards STEAM	4 questions	Descriptive statistics: percentile and Friedman test
		Considering the STEAM areas	5 questions	Friedman test
		Self-efficacy in planning STEAM activities (first measure)	1 question	Used afterwards in a pre-post-test design
STEAM activity plan		Application of each STEAM area Application of active learning teaching methods	14 STEAM activity plans	McNemar test Descriptive statistics
Survey II	Part A	Self-efficacy in planning STEAM activities (second measure)	1 question	Wilcoxon Signed Ranks test
	Part B	Open-ended questions	5 questions	Multiple comparisons on Ground Theory

18 educational approaches were aggregated into a single scale variable ranging between 18 and 90 (survey I, part A). This variable was repeatedly measured on different dimensions: Knowledge, Usage, Willing to use, and Appropriateness to STEAM. On the dimension of Knowledge, for example, the greater the value of this variable, the more teachers agree on knowing a large variety of educational approaches.

After this variable was created, we run a Friedman test. This nonparametric test was used to verify differences within subjects from one single sample, considering repeated measures on more than two different conditions (Lawson et al., 2019), the four mentioned dimensions, in our case. We preferred nonparametric tests throughout the research because of the small sample size or variable ordinal level measurement.

Specific observations (non aggregated) were done in this same part of the instrument, so each educational approach was treated as a variable (ordinal level). They were represented graphically on R Studio Statistics using the Likert library. Then multiple Wilcoxon signed-rank tests compared each educational approach considering only two dimensions at a time. Similarly to the Friedman test, Wilcoxon signed-rank test is used to verify differences within subjects from one single sample, only between two conditions though (Lawson et al., 2019). This test was used to verify differences in repeated measures regarding the four dimensions, two at a time.

In part B of survey I, we used descriptive statistics of a list of 15 possible positive STEAM impacts, and four items about predisposition towards STEAM. After, a Friedman test verified differences in teachers' self-efficacy in considering each STEAM knowledge area in the STEAM plans. The question about general self-efficacy in planning STEAM activities was reserved to be used afterwards in a pre-post-test design.

We analyzed the content of the STEAM plans teachers developed. For that, five binomial variables were created for each STEAM knowledge area (with levels: presence and absence). Then, the knowledge areas were accounted for as present/absent in the STEAM plans. This information was contrasted with teachers' self-efficacy in considering each one of those STEAM areas (data from survey I). These variables were also converted into binomial ones. For example, participants who had asserted efficacy in considering the knowledge area in the plan were accounted for the value "presence". After this preparation, a McNemmar Test was run to verify a significant change in teachers' initial self-efficacy in considering each STEAM knowledge area to its actual usage in the plans. This test was chosen because it permits verifying changes in paired binomial data (Pembury Smith & Ruxton, 2020).

Similarly, we analyzed the usage of active learning teaching methods in the STEAM plans. This information was crossed with teachers' prior use of that teaching method, as indicated in part A of the survey I in the dimension of Usage.

Finally, in part A of survey II, a Wilcoxon Signed Ranks Test was run in a pre-post-test to verify a change in self-efficacy in planning STEAM activities. Part B of this instrument was qualitative. In this part, open-ended questions were analysed through multiple comparisons, then categories were induced as established by Ground Theory (Strauss & Corbin, 1994). We did a first scan reading; then subsequent readings to draft and refine categories, by merging or splitting them whenever necessary. This process iterates until saturation is reached. Finally, we calculated the incidence frequency of each category, and we select representative answers which qualify them.

RESULTS

Results are organized in the same order as presented in the data analysis subtopic, and they sequentially address our research questions. Therefore, you are invited to read from this point with our first inquiry in mind - What are teachers' initial opinions related to STEAM Education?

As previously explained in the data analysis topic, we aggregated data from 18 educational approaches into a single variable. This variable captures teachers' evaluation of the variety of those educational approaches. As result, the dimension of Usage had a mean rank of 1.07, followed by Knowledge, with a mean rank of 2.07. Willing to use and Appropriateness to STEAM had mean ranks of 3.32 and 3.34. A Friedman test indicated significant differences regarding those four dimensions ($\chi2$ (14) = 33.6, p = .001). In other words, teachers are willing to use and think a broader variety of educational approaches is Appropriate to STEAM, than they actually know and practice.

This data was further analyzed for more specific information. First, we addressed it through visual insight. For that, Figure 1 presents teachers' evaluation of the same 18 educational approaches regarding four dimensions: Knowledge, Usage Willing to use, and Appropriateness to STEAM. On the top of the graphs are positioned the most asserted educational approaches, and at the bottom are the approaches rated with more disagreement. Agreement, neutrality, and disagreement frequency percentages are shown on the right, middle and left sides respectively.

Visually, comparing the green areas of the graphs is possible to perceive teachers seem to have asserted more Knowledge than Usage. Results show agreement frequency on Knowledge superior to 70% on five educational approaches. In contrast, only direct instruction presents an agreement frequency superior to 70% in the dimension of Usage.

Regarding the dimensions of Willing to use and Appropriateness to STEAM, both graphs indicate a high tendency toward the agreement pole (green colour) for educational approaches. In fact, most educational approaches have an agreement frequency superior to 70% in the two dimensions.

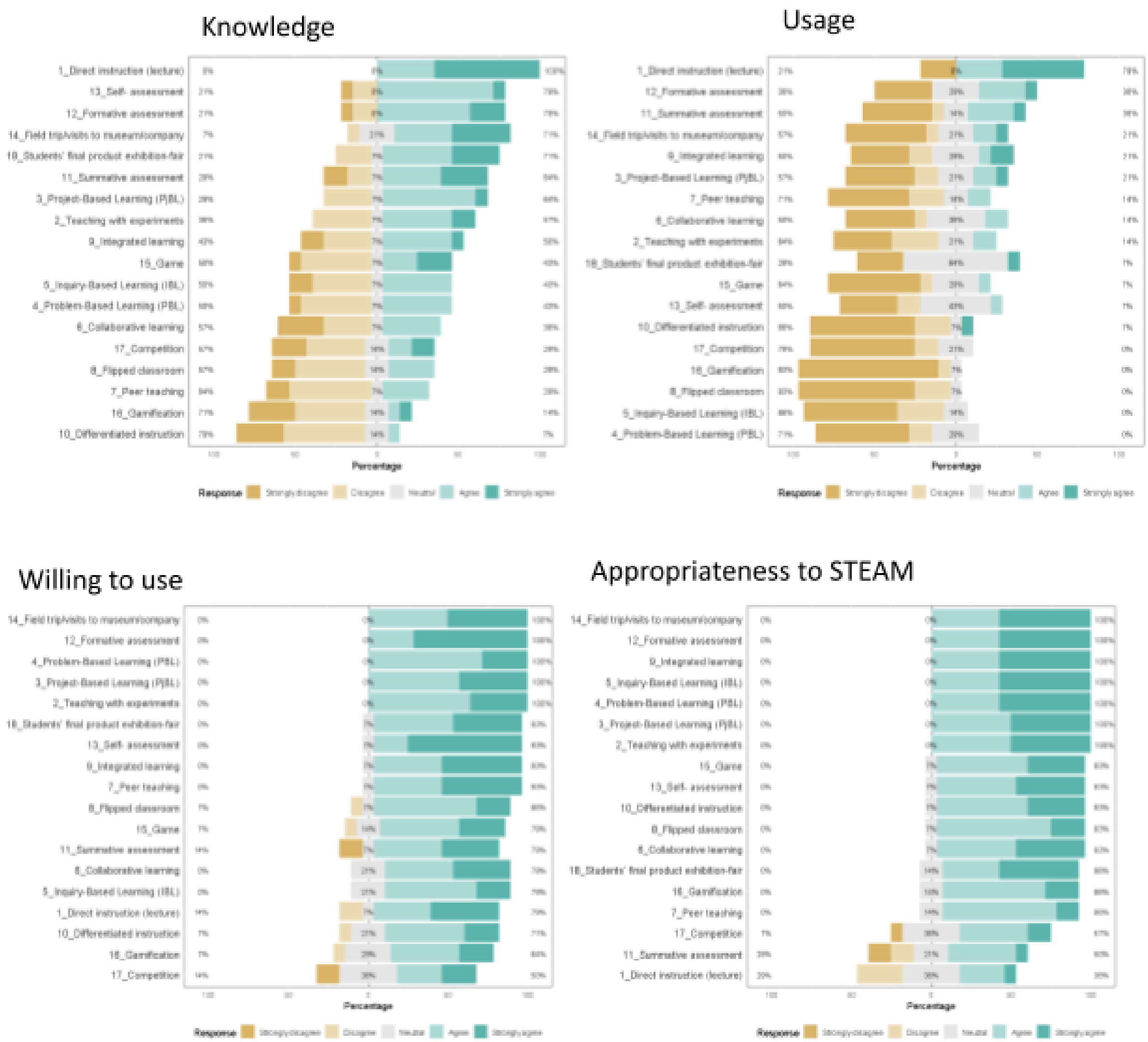

Figure 1
Teachers' opinions about 18 educational approaches regarding the dimensions of Knowledge, Usage, Willing to use, and Appropriateness to STEAM.

Now considering only two conditions at a time. As shown in the first columns of Table 3, there was evidence Knowledge had a superior agreement rate compared to Usage in most educational approaches.

Table 3

Wilcoxon Signed-Rank test on 18 educational approaches regarding the dimensions Knowledge (K), Usage (U), Willing to use (W), and Appropriateness to STEAM (A).

Educational approach	K vs U		W vs A		K vs A		U vs A	
	Z	p value	Z	p value	Z	p value	Z	p value
Collaborative learning	- .97b	NS	-1.00b	NS	-3.09b	<.05	-3.21b	<.05
Competition	-2.40b	<.05	-.614b	NS	-1.48b	NS	-3.10b	<.05
Differentiated instruction	-1.25b	NS	-1.47b	NS	-3.37b	<.05	-3.25b	<.05
Direct instruction	-1.80b	NS	-2.75c	<.05	-3.02c	<.05	-1.35c	NS
Teaching with experiments	-2.68b	<.05	-.71b	NS	-2.46b	<.05	-3.37b	<.05
Flipped classroom	-3.07b	<.05	-.63b	NS	-2.97b	<.05	-3.41b	<.05
Field trip/visits to museum/company	-3.15b	<.05	-.45b	NS	-2.33b	<.05	-3.20b	<.05
Final product exhibition	-2.80b	<.05	.00d	NS	-1.45b	NS	-2.98b	<.05
Formative assessment	-2.97b	<.05	-.63c	NS	-2.41b	<.05	-2.95b	<.05
Game	-2.80b	<.05	-.90b	NS	-2.33b	<.05	-3.33b	<.05
Gamification	-2.91b	<.05	-1.00b	NS	-3.13b	<.05	-3.38b	<.05
Inquiry-Based Learning (IBL)	-2.88b	<.05	-2.00b	<.05	-2.96b	<.05	-3.40b	<.05
Integrated learning	-1.21b	NS	-.58b	NS	-2.68b	<.05	-2.92b	<.05
Problem-Based Learning (PBL)	-2.91b	<.05	-1.41b	NS	-2.96b	<.05	-3.35b	<.05
Peer teaching	-1.78b	NS	-1.90c	NS	-2.85b	<.05	-3.10b	<.05
Project-Based Learning (PjBL)	-3.07b	<.05	-.38b	NS	-2.72b	<.05	-3.08b	<.05
Self- assessment	-2.99b	<.05	-1.41c	NS	-2.07b	<.05	-3.11b	<.05
Summative assessment	-2.75b	<.05	-2.64c	<.05	-.72c	NS	-1.11b	NS

b. Based on positive ranks. c. Based on negative ranks. NS. Non-significant

We decided to present differences between Knowledge and Appropriateness to STEAM, and between Usage and Appropriateness to STEAM. The combinations Knowledge and Willing to use, and Usage and Willing to use were omitted because Wilcoxon Signed Rank tests indicated teachers evaluated Willing to use and Appropriateness to STEAM similarly.

Comparison of Knowledge and Appropriateness to STEAM shows most approaches presented significant differences. We highlight direct instruction was calculated based on negative ranks. According to the sequence in which the test was designed, that imply although teachers indicated they know, they don't consider this educational approach so appropriate to STEAM.

Last, Wilcoxon Signed Rank tests were run regarding Usage and Appropriateness to STEAM. Most approaches show significant differences. They were calculated based on positive ranks. By the order of the test, it denotes teachers attributed higher rates to Appropriateness to STEAM than its Usage.

Teachers' opinion on STEAM Education's impact was evaluated through a list of 15 items. Table 4 list them in a rank order, starting from the most positively evaluated. We highlight the medians of all aspects lay in the values 4 (Agree) and 5 (Strongly agree). This result points to teachers' overall positive evaluation of STEAM Education's impact.

Table 4

Teachers' opinion on STEAM Education impact.

Impact of STEAM Education	Percentiles		
	25th	50th (Median)	75th
Students develop interdisciplinary knowledge (STEAM literacy)	4	5	5
Students develop creative thinking	4	5	5
Students develop interpersonal skills and cooperative work	4	5	5
Students focus more on their learning	4	4,5	5
Students feel more autonomous in their learning	4	4	5
Students develop critical thinking	4	4	5
Gives significance to learning while connected to the student's context/reality	4	4	5
Students more easily remember what they learned	4	4	5
Reduces the gap between boys and girls in STEM	3	4	5
Students effort more into what they are learning	3,75	4	5
Ethical/human values development	4	4	4,25
Students have an environment of error as a learning opportunity	4	4	4
Students understand more easily what they are learning	3	4	4,25
Encourages environmental education	3	4	4,25
Classroom climate is improved (fewer indiscipline problems)	3	4	4

Furthermore, teachers answered four questions directly intended to explore their predisposition toward STEAM: 1) I intend to further develop my skills in STEAM; 2) I am willing to use STEAM Education; 3) I am interested in advanced programs involving STEAM, and 4) I would recommend STEAM Education to my fellow teachers. Responses to those questions had medians of 4 (Agree) and 5 (Strongly agree). This result indicates teachers' predisposition toward STEAM.

Now we remind the reader of our second research question – How did the teacher training program affect teachers' abilities on planning STEAM activities?

Still regarding survey I, we explored teachers' self-efficacy in applying the knowledge areas of Science, Technology, Engineering, Arts/humanities, and Mathematics in STEAM plans. Results show they mostly indicated self-efficacy in considering Arts and Humanities, Mathematics, and Science (percentile 50th = 4, agree), but they disagreed about Engineering and Technology (percentile 50^{th} = 2, disagree). A Friedman test confirmed those differences between areas were significant (Friedman $\chi 2$ (4) = 13.77, p = .008). The sixth question of this block addressed teachers' self-efficacy in planning STEAM activities (in general), this data will be used afterwards in a pre-post-test design.

Now on, we present the result analysis of data collected at the end of the program. The 14 STEAM plans teachers developed were analysed to verify which STEAM areas and which active learning teaching methods were applied. Results showed all plans contained at least the areas of Science and Art/Humanities. Moreover, half of them involved the five STEAM areas. This finding indicates teachers embraced the interdisciplinarity enterprise.

A McNemar test verified whether there is a change between teachers' initial self-efficacy in considering each area of STEAM (from the survey I) and their actual use in the plans. Engineering was the sole area with a statistically significant change ($\chi2$ (1) = 4.9, $p = .03$). Nine teachers who had indicated low efficacy in considering Engineering then applied it to the STEAM plan.

Despite having a non-significative change, it is noteworthy to observe three teachers indicated efficacy in considering Technology initially, but they didn't use it in their plan. Similarly, five teachers who had indicated efficacy in considering Mathematics didn't use it as well. We should remember most participants are from the area of Humanities. Non-use of some knowledge areas in the plans does not mean necessarily a negative signal. It can be interpreted as the learning that in STEAM the knowledge areas must be used substantially, instead of in a superficial approach.

Regarding the application of active learning teaching methodologies, teachers applied Inquiry-Based Learning (6), Project-Based Learning (5), and Game-Based Learning (1) in their STEAM plans. This information was crossed with each participant's response on prior use of that specific teaching methodology (data extracted from part A of the survey I within the dimension Usage. The result indicated that 71% of the teachers applied teaching methodologies in the STEAM plans they were not habituated to using.

From this point, we present an analysis of part A of survey II. This part had a repeated measure of teachers' self-efficacy in planning STEAM activities. Initially, teachers indicated a median of 3, meaning "Neutral" (survey I); and after the program, it changed to 4, meaning "Agree" on self-efficacy in planning STEAM activities. A Wilcoxon Signed Ranks Test showed this difference was statistically significant ($Z = - 3.071$, $p = .002$).

From a more qualitative perspective, five open-ended questions explored the process of planning STEAM activities (part B of survey II). In Table 5, each question is presented as a topic followed by the categories induced from data and its representative responses.

Table 5

Teachers' opinions after enrolling in a program on planning STEAM activities.

Topic		Category	Representative response
Difficulty in doing STEAM activity plans		Merging different knowledge areas (10)	"Significant inclusion and integration of STEAM areas into plans" (P10).
		Setting a teaching method (3)	"Defining the appropriate methodological approach to the activity" (P12).
		School management resistance (2)	"considering the receptivity of the school management" (P01).
Pros and cons of STEAM Education	Pros	Interdisciplinarity (9)	"Teachers can connect a content to other knowledge areas" (P02).
		Authentic context and connexion to students' reality (5)	"STEAM fosters new or creative connections with the real world and contextualized problems" (P10).
		Variety of teaching methods (4)	"We can integrate STEAM areas while using teaching methods other than direct instruction" (P07).
	Cons	Time-consuming (3)	"STEAM requires a greater effort to plan the activities" (P02).
		Lack of expertise in some areas (2)	"Teachers are required to have competence in more knowledge areas" (5).
		Risk of content superficiality (1)	"The content might stay shallow" (P09).
Positive aspects of doing a STEAM activity plan		Incentive learning about other areas (5)	"It encourages professors to learn about areas beyond their disciplines" (P02).
		Planning ability (5)	"Teachers can exercise a critical eye on their plans. They need clear, complete and coherent objectives to do STEAM" (P10).
		Learning collaboratively (2)	"Knowledge and experience exchanges allow exploring the potential of colleagues" (P03).
		Learning about STEAM Education (1)	"Learning more about STEAM" (P07).
Suggestion to STEAM		Teacher training (6)	"The concepts of STEAM should be taught and disclosed" (P06).
		Revise the presence of Humanities (2)	"Most STEAM cases cover exclusively the areas of technology and engineering, while Humanities play a secondary and illustrative role" (P01).
		Approximating professionals from Engineering and Technology (1)	"Strengthen the relationship between professionals from engineering and technology professionals and education" (P03).
Teachers' required abilities for pursuing STEAM Education		Openness to changes and continuous learning (9)	"Teachers need to be open to learning new ways of working" (P07).
		Collaborative ability (3)	"Teamwork and collaboration, availability to learn new methodologies" (P13).
		Using technological tools in education (3)	"Teachers need to know about technological tools in education" (P05).

The first question was – What is the most difficult part of making STEAM activity plans? Results showed merging different knowledge areas seems to be the harder part, stated by 10 teachers. They also cited setting a teaching method and school management resistance.

On the other hand, interdisciplinarity was the most frequent category about the pros of STEAM Education, with nice citations. Teachers also mentioned authentic context and connexion to students' reality and a variety of teaching methods as advantages of STEAM. Few teachers stated about cons of STEAM Education: time-consuming, teachers' lack of expertise in some knowledge areas, and risk of working content superficially.

The third question directly relates to their learning experience in planning STEAM activities. They were asked, – What was a positive aspect of directly developing STEAM materials as a pre-service teacher? Most teachers highlighted incentives for learning about other knowledge areas and developing planning ability. Also learning collaboratively, and learning about STEAM Education.

The fourth question analysed was – What is your suggestion for STEAM education after you developed STEAM materials for yourself? Their answers indicated the necessity of teacher training on STEAM, followed by revising the presence of Humanities. One teacher suggested approximating professionals from Engineering and Technology to the school.

Finally, yet importantly, the question - What kind of abilities do you think teachers need for STEAM Education after you developed STEAM materials for yourself? Nine teachers pointed to openness to changes and continuous learning. Teachers mentioned collaborative ability (3), and the efficacy of using technological tools in education (3).

DISCUSSION

What are teachers' initial opinions related to STEAM Education?

Results showed a significant global difference between teachers' evaluation of educational approaches considering the dimensions of Knowledge, Usage, Willing to use and Appropriateness to STEAM. Specific tests demonstrated a congruency between what teachers indicate they are willing to use and what they consider appropriate to STEAM Education. In fact, most educational approaches had no significant difference between those two dimensions.

The difference lies principally when comparing Knowledge to Usage, and when comparing each one of them with Appropriateness to STEAM. We cannot affirm whether the level of teachers' knowledge of those educational approaches was sufficient for their application. Park et al. (2016) point to a mismatch between teachers' perception and actual practices in STEAM Education. In this sense, general feeling of insufficient experience and knowledge of STEAM

Education may negatively affect its inclusion in curriculums at all school levels.

In the opposite sense to most educational approaches, direct instruction was, on one hand, the most known and commonly used educational approach, but on the other hand, teachers are not so willing to use it, and it was the least evaluated approach in terms of appropriateness to STEAM. Interestingly, that shows an open avenue to explore other teaching methods.

Teachers agreed regarding a list of 15 positive impacts of STEAM. This result suggests a positive view of STEAM education. Additionally, as stated before, there was congruency between what they are willing to use and what they consider appropriate to STEAM. Corroborating to all that, they agreed with four questions directly related to predispositions toward STEAM. Rodrigues-Silva and Alsina (2021) argue teachers' beliefs, prior knowledge and experiences should be considered in their professional development. Accordingly, in the first stage of the course, teachers were able to share ideas and concerns about STEAM.

How did the program affect teachers' abilities on planning STEAM activities?

Teachers' self-efficacy about considering STEAM areas in STEAM plans was heterogeneous. They agreed on efficacy in considering Art/humanities, Mathematics and Science, but disagreed about Engineering and Technology. Other studies show teachers have difficulty differentiating Engineering and Technology (Kim & Bolger, 2017). Thus, a teacher's suggestion on approximating professionals from Engineering and Technology to the school seems rather pertinent.

Teachers' efficacy in considering Engineering in STEAM plans had a significant increase. Nine teachers who had indicated low efficacy then considered this knowledge are in their STEAM plans. Researchers agree planning STEAM is challenging for teachers (Boice et al., 2021; Cook et al., 2020). Accordingly, merging different knowledge areas was the most frequent category on the open-ended question about difficulties in doing STEAM plans. This is a frequently reported issue in the literature (Carmona-Mesa et al., 2019; Cook et al., 2020)

In spite of the difficulty, teachers indicated interdisciplinarity as an advantage of STEAM Education and doing STEAM plans incentives them to learn about other knowledge areas. There was evidence they overcame this difficulty, half of the STEAM plans embraced the five STEAM areas. Art/Humanities and Science were present in all of them.

Similarly, they reported setting a teaching method as being a difficult aspect when doing STEAM activities plans in the open-end questions. Interestingly, they also pointed variety of teaching methods as an advantage of STEAM Education. Analysis of the STEAM plans confirmed they applied active learning teaching methods, especially inquiry and project-based learning. It is noteworthy to say more than 70% of them used teaching methods that were new to them. A teacher wrote –"We can integrate STEAM areas while using teaching methods other than direct instruction" (P07). Those findings show teachers may consider interdisciplinarity and active learning teaching methods challenging. But they support them as advantages of STEAM, and they were able to surpass those difficulties through the STEAM plans.

Teachers' achievements are intimately connected to the teacher training program features. In the beginning, there were sessions on theoretical scaffolding on STEAM and active learning teaching methods. Afterwards, this theory helped teachers to develop STEAM plans. In addition, the two rounds of feedback (with mentoring) and the peer and self-assessment were redirected teachers' so they could accomplish the STEAM plans. For example, they were demanded to apply the STEAM areas in an interdisciplinary manner, wherein one area was neither addressed superficially nor with a subservient role. They were also suggested to investigate and explicit the teaching method used.

Of course, all that process is laborious, especially when teachers are still developing the abilities to plan STEAM activities. Accordingly, they warned time-consuming might be a disadvantage of STEAM Education. That concern is reported by authors from other countries, such as in Korea (Park et al., 2016).

CONCLUSION

Teachers' self-efficacy in planning STEAM activities augmented significantly with the training program, from percentile 3, meaning neutral, to 4, agreement. They confirmed in an open-ended question the development of planning ability is a positive aspect of doing STEAM activity plans. Participants indicated openness to changes and continuous learning as a required ability for teachers for pursuing STEAM Education. Accordingly, their most frequent suggestion for STEAM education was teacher training. At this point, we recall the gap between teachers' knowledge of educational approaches and their appropriateness to STEAM.

Results allowed us to conclude this online teacher-training program on planning STEAM activities allowed teachers to explore active learning teaching methods, augmented their self-efficacy in considering the STEAM areas in the plans, and in conclusion, was able to conduct teachers to accomplish the task of planning STEAM activities.

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