Mathematical and Computational Thinking from a STEAM Proposal: is the Practitioner's Teaching Profile and Educational Capabilities Developed?

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Abstract

The multidisciplinary approach can develop more potential and attractive teaching skills and attitudes in teachers due to its flexible and adaptive condition of didactics and curricular contents as opposed to non-integrative constructionist didactics. A multidisciplinary STEAM project for practicing teachers (n = 18) versus constructionist teaching (n = 17) was implemented, and computational thinking and school mathematical thinking were tested. The total number of participants was 913 schoolchildren, who participated in a longitudinal comparative methodology. The group comparison reported effects of the STEAM Integration Programme, which showed that the skills of practicing teachers were more effective than those of teachers who followed the university training scheme (classical constructionism). Among the longitudinal evidence, a greater speed of development of cognitive tasks was found in the last three months of application of the STEAM Project, and operational and testing skills improved, showing a greater effect of the strategies on computational thinking than on mathematical thinking skills.

Keywords

Computational learning, mathematics, multidisciplinary teaching, pedagogical practice.

1. Introduction

The teaching of teachers specializing in science teaching has many strengths centered on the use of didactics. However, although it is practiced under the competency-based learning approach, it still presents problems in generating learning using technological tools that broaden learning and different ways of thinking. In this opportunity, we investigate the teaching profile of teachers who practice STEM in the development of mathematical and computational thinking. In addition to this, the development of virtual and blended learning classes is considered more of an impediment than an option for educational progress compared to face-to-face education. The current problem stems from the social concern that more than 400 million students no longer receive face-to-face education, in addition to the lack of initiatives to regulate distance education with face-to-face education in different countries around the world [1, 2].

In Callao regional education, the increase in technology has not been balanced with the competencies that teachers specialized in mathematics and science education should develop. Thus, less than 30 % of teachers reflect on their teaching methods in accordance with the Good Teaching Performance Framework [3]; and this problem has been accentuated since before the pandemic, with more than 20 % of the school's educators demonstrating deficient digital competencies [4]. This is totally deplorable compared to other studies in which teacher innovation can improve their distance teaching skills by making them feel more self-effective in teaching tasks [5]. In the field of science education there is still a gap between STEM teaching and the STEAM product for developing human cognition [6], to some extent because cross-disciplinary experimental methodologies reduce the model of monitoring experiences during

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longitudinal experiments, as was the case in a study where students' needs were verified during two years of computational thinking research [7].

Specifically, from the perspective of educational management, it is known that these competences for teaching mathematics and computing are integrated into the global competences for educating in social coexistence [8, 9], despite the fact that the teaching of science and mathematics always share cognitive, affective and motivational aspects.

1.1 Mathematical and computational thinking from virtual STEM practices

Computational thinking is understood as the group of cognitive abilities that allow the subject to solve problems using computers, thus benefiting from the understanding of science, technology and mathematics [10, 11]. Some studies identify abilities of decomposition, algorithmisation, abstraction and pattern recognition [12, 13, 14]. In that sense, the ability to decompose allows extracting similar parts of a complex problem in order to analyze it according to its structural components. Abstraction allows the reduction of quantities to more complex units from the use of information [14]. In algorithmisation it allows the individual to solve problems by formulating algorithms to achieve a goal-oriented solution. In pattern counting, the developer develops systematic models of the information using the developed algorithms. Thus, it has been found that programming includes the achievement of ideas that students employ from understanding information and formulating new solutions [15, 16]. Similarly, information understood and structured through programming generates knowledge about various resources and artefacts for the learner and teacher as they interact [17, 18]. Computational feedback enhances the voluntary ability to develop more efficient programming and problem solving in creative game making [18, 19, 20].

As for mathematical thinking, it has already been considered as the set of abilities to discriminate information through analysis with specific criteria, in order to solve problems [10; 21, 22]. To all this, current research reveals that didactic guidance needs to be more active, even more interactive in whose verbal teacher-student transactions include high-level techniques, concepts and processes for the understanding of mathematical information. From this, constructionist activities are derived from the use of virtual elements, however, this interaction could be unusually effective when guiding students with instructions in this interactive process [23]; furthermore, it also occurs when emotional factors are conducted in an instructional way, moreover, collaborative activities based on the use of games also reduce anxiety as opposed to the vectors of boredom and stress that mathematics generates. This also occurs in the use of computer-based virtual environments [24, 25]. Although the digital constructionist or constructivist perspective differs from instructional models, these proposals have already been compared with activities that introduce programming classes to the development of mathematical thinking, relying on the attractions of virtual learning objects as well as information demonstrated in synthesis and graphically [26]. Proposals can be followed that refer to creativity and art as a contributing component in STEM activities by trying to liberate students' transdisciplinary activities [6], use their interactions according to the nature of games and their socio-scientific teaching virtues, and involve interdisciplinary science-arts-technology and mathematics activities to strengthen logical reasoning and the decoding of arithmetic information [16, 27].

1.2 Teacher profile: evidence from classroom teaching

The teacher profile is the multifactorial component that enables effective pedagogical management in the classroom. Current literature refers to it as the set of domains and attitudes for executing teaching processes characterized according to the subjects or curricular areas in which they are developed [8], therefore, they are structured in procedural, attitudinal and cognitive knowledge [8, 28]. Current findings have studied its nature in the UK and China, understanding it as a process of transferring learning skills from the teacher to the learner that includes reflective and self-critical stages when they engage in an interactive activity [9, 28, 29].

When this is demonstrated in the didactic activity itself, it proceeds with a subsequent activity, which is a factor of pedagogical evaluation, in which the teacher has the ability of self-knowledge and acculturation [29, 30, 31]. This means knowing the feasibilities of their teaching, their weaknesses, as well as the contents with which to adapt their teaching to the goals of the area studied. In this sense, Holzberger's studies have succeeded in proposing three characteristics in which these components are included and which correspond to these two moments [8, 32, 33]: (a) motivational characteristics, (b) affective characteristics, (c) cognitive characteristics.

STEAM is an interdisciplinary approach that is included in few educational institutions in Peru as part of a didactic curriculum, functioning more as an optional method for science or mathematics teachers. In this opportunity we hypothetically propose the development of the teaching profile of teachers who carry out pre-professional practices in science, but are those who seek to specialize in multidisciplinary teaching from the application of the STEM approach with mathematical, scientific, artistic and computational activities. In this sense, computer-based activities are included through the acculturation of teachers, following studies where it was found that the profile can be more innovative with this experience [29, 32]. Without neglecting that this science works in the school thinking of the students they are in charge of, adapting the proposal of El Bedewy & Lavicza [6] with the multidisciplinary STEAM approach. The aim of this research focused on the longitudinal study of the development of the multidisciplinary professional profile (during a period of pre-professional internships) and the development of mathematical and computational thinking of public-school students.

2. Method

2.1 Sample and materials

The experimental method applied led to the selection of two evolutionary groups, considering the study of Kong & Wang [11]. We adapted this experience with a team of postgraduate students in Primary Education, who carried out their pre-professional internships during two semesters of study. This feature sought to allow exploration of the teaching profile and student cognition longitudinally, so that teachers aiming to specialize in multidisciplinary STEAM pedagogy will discover the eventual needs of their students in charge, in the application of their didactics at the center of their professional practice. The sample consisted of 35 subjects, which made up two groups of student practitioners (experimental $_{(STEAM)}$ = 18; control $_{(constructionist)}$ = 17). The teachers were in charge of 913 students attending 21 public educational institutions of regular basic education (IV cycle $_{(M)}$ = 8,2; SD = 0,21; V cycle $_{(M)}$ = 9,31; SD = 0,13) (experimental $_{(STEAM)}$ = 415; control $_{(constructionist)}$ = 498). These functioned as practice centers for two academic semesters of practice for university students, and represented one school year for school students. The university students were in the last two cycles of primary education (IX and X: according to the curriculum map). The methodology of the experimental group was multidisciplinary (STEAM) and that of the control group was traditional constructionist (used in the Peruvian educational system). All the university students agreed to their inclusion through the report given in the final practice course. Also, the included students were selected and informed of the study through their academic tutors. The informed consent form was signed by parents agreeing to their children's participation.

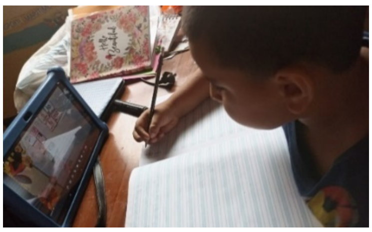
The measurement of the competences of the multidisciplinary profile was carried out with monitoring and self-administration instruments. In the first case, the *Multidisciplinary teaching profile rubric* (MULTEP-R) and the *Teacher profile characterization scale* (TPC-S) were used. These documents were developed ad hoc in conjunction with the science and technology monitors, who were part of the pre-professional practice supervision group of a private university in Lima. The components evaluated with MULTEP-R were: (a) Multidisciplinary knowledge, (b) Methodology for multidisciplinary teaching. TPC-S included: (a) Cognitive characteristics, (b) Motivational characteristics, (c) Affective characteristics. The constructional approach of these instruments adhered to the approach proposed by Holzberger et al. [8]. The first instrument consisted of 25 items and the second of 20. The content validation was carried out with the judgement of 10 experts, whereby an Aiken index was calculated, whereby the items of each instrument exceeded the value of 0.70 in 4 of the dimensions assessed. On the other hand, the affective factor of the TPC-S presented a value of 0.91 as a unidimensional scale. In this case, as we considered instruments that measured progressive assessment, we opted for a test-retest correlation, in order to validate its temporal consistency eight months after the proposal was developed. The Pearson correlations presented significant values, considering the minimum and maximum values from an average taken from each assessment (pretest and posttest).

Computational and mathematical thinking was assessed with a performance test scored with a rubric for each dimension. This allowed the results and procedure of each subject to be graded, which involved assessing computational solving tasks. The tasks were designed to measure the abilities of each subject in using each type of thinking. In mathematical thinking, tasks were developed for: (a) abstraction, (b) deduction, (c) development, (d) generalization, (e) synthesis, (f) induction, (g) analogy. For computational thinking: (a) decomposition, (b) pattern recognition, (c) abstraction, (d) algorithm development. In view of the dimensional complexity, the following dimensions were considered to measure each group of implemented tasks: (1) solving time, (2) operational development, (3) solution and testing. These dimensions were corroborated by the classroom exercise teachers in co-ordination with the assigned practitioners in the laboratories of each school. An initial application on subjects not considered in the sample reported acceptable reliability indices (Time to Resolution = 0.81; Operational Development = 0.79; Solution and Verification = 0.83).

To avoid biases on the school performance tests, changes were made to some tasks six months into the experience, as well as in the eighth month. This was in order to allow the prior knowledge factor to influence the final results. The approach and validation process was carried out following the validation procedures carried out with the initial version.

2.2 Procedure

The reports obtained from the assessment instruments of the multidisciplinary practice in education were sent weekly to the head of practice at the university, in order to make compilations and monthly reports on the progress of the work. Instead, the reporting of school students' data was recorded every weekend in a Google Drive database. Using this data, the researchers calculated the average monthly progress for each comparison group, both in terms of the teacher's score and the schoolchildren's score. On the other hand, the proposal was developed with a projection of a school year, being executed in the practice center for 10 months. The STEAM practice was developed from three educational vectors in the area of science with integrated projects in the areas of art, the development of logic and displacement, the use of seeds and the development of computerized mathematical tasks. The central theme that led the integrative project was entitled: "*Intercultural seeds for the understanding of emotions and of soil, water and air*". The sub-thematic areas involved the use of diverse resources: tablets, seeds, basic agronomy tools, paper, colors, digital tablets, computers, printers... (figure 1).



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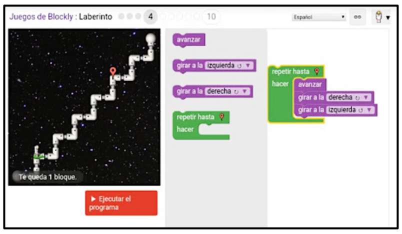

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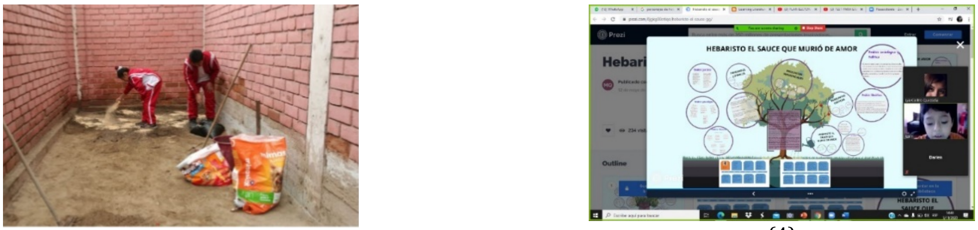


(3) (4)

Figure 1: Activities and resources used according to the school area (exemplification).
Note. rt and communication: representing care for the environment with syllabic content using tablets, (2) Mathematics and Creative location of crops with phase 1: Maze, de Blocky Games: https://blockly.games/, (3) Science and technology: sowing seeds, (4) Communication and art: collaborative reading of texts in Zoom environment, play: "*Hebaristo, el Sauce que murió de* Amor" by Abraham Valdelomar, Peru.

In that sense, the multidisciplinary teaching of the practicing teachers involved the use of contents developed in science and technology and in other areas according to the weekly hours dedicated by each particular area (table 1). This project adhered easily to the didactic projects applied at the same time in each classroom of the experimental group.

Table 1
Sub-themes addressed in the multidisciplinary project

Area	Curricular themes	Sub-themes	Duration (teaching hours) *
Arts	Drawing and painting	Expressing emotions with drawings on tablets	2
Science and technology	Inquiry and scientific skills	Developing renewed vegetable gardens with knowledge about regional crops	3
Mathematics	Problem solving and statistics	Application of counting and basic statistical operations for the achievement of sowing and knowledge of minerals	3
Personal Social	Recognition of the body and the environment	Development of digital presentations representative of the environment and human habitat	2
Communication	Written and verbal communication skills	Representation of iconographic contents on the care of the environment and crops	2

Note. * Hours per week = 12. Curricular hours (per week) = 23. The contents were integrated into the 10 hours of work per week, allowing the classroom teachers to carry out their classes in the traditional way during the curricular hours. This prevented the integration project from becoming an obstacle and biasing the experiment.

The pedagogical activities were included as part of the didactic development of each classroom, implemented with teaching sessions applied through didactic phases of beginning, process and end. The initial phase consisted of dynamic and problem-solving activities integrating at least two areas, the process phase consisted of constructive processes involving the development of multidisciplinary activities originating from three areas. In the control group, traditional didactic units were applied. During the year they developed three didactic projects without applying multidisciplinary content in the classroom. During this period, teachers assigned to the control group implemented constructivist pedagogical actions using contemporary pedagogical knowledge.

3. Results and discussion.

In the group of trainee teachers, the range of the multidisciplinary teaching profile was between 75 and 25 points (MULTEP-R). Self-perception ranged between 60 and 20. These measures were categorized for the two comparison groups. In the group of school students, the group average for task solving in computational thinking was 3.19 minutes in the experimental group, and 3.21 in the control group. In mathematical thinking, this measure averaged 4.01 minutes in the experimental group and 4.35 minutes in the control group. It should be borne in mind that these are measures averaged over the 10 assessments performed in the experimental approach.

Comparative measurements: control and experimental group

The pretest assessment scores of the multidisciplinary teaching profile showed non-significant differences between the averages of the multidisciplinary and constructionist teaching groups ($t_{(33)}$ = 0,58; Diff. = 1,02; p >.05) (table 2). After the professional practice, that is to say, in the evaluation after 10 months of application, the differences were significant between these groups, with a higher increase in the experimental group (multidisciplinary teaching) ($t_{(34)}$ = 1,33; diff. = 23,02; p <.05). Table 2 shows the intra-group comparisons, showing a significant improvement in the experimental group with an average of more than 20 points, which demonstrates the significant improvement of the experimental group compared to the control group, where the improvement of four average points did not mean a significant difference in the statistical analysis. In the analysis of self-perception, it was possible to corroborate non-significant intergroup differences in favor of the experimental group ($t_{(32)}$ = 0,71; diff. = 1,05; p >.05).

Table 2
Averages obtained from the multidisciplinary teaching profile assessments in MULTEP-R and TPC-S

Teaching profile and self-perception	M (SD) [Pretest]	M (SD) [Posttest]
EG (multidisciplinary) [MULTEP-R]	34 (0.34)	62 (0.45)*
CG (constructionist) [MULTEP-R]	35 (0.51)	39 (0.40)
EG (multidisciplinary) [TPC-S]	41 (0.52)	56 (0.41)*
CG (constructionist) [TPC-S]	40 (0.39)	49 (0.35)*

Note. * $p < 0.05$.

At the end of the implementation of the integrative project, values were found that indicated intergroup differences in favor of the subjects in the experimental group ($t_{(34)}$ = 1,59; dff. = 8,07; p <.05). It should be noted that in the individual differences both the subjects of the experimental group (multidisciplinary approach) and the control group (constructionist approach) presented significant differences in the self-perceptual aspect of the profile (table 2). Thus, these first references are consistent with different characteristics that practicing teachers can use when working on integrated projects such as the intercultural seeds project. Other studies show that, while it is true that collaborative activities produce better ideas and solutions to learning problems than individualistic ones [24, 26, 27], it is important to differentiate whether the type of experience is instructionalist without having varied content from which to acquire new information. Learning becomes more meaningful to students when it is available in the different media used in a single lesson, as was the case in the STEAM multidisciplinary teaching approach. This research has been able to demonstrate that constructionist activities of disciplinary-focused didactic units have less effect on teachers' adaptation when they seek to make didactic integrations of content, which pleases students as they learn in favor of their needs and styles to learn by will [18, 19].

Table 3
Averages obtained from the mathematical and computational thinking assessments

Groups and types of thinking*	M (SD) [Pretest]	M (SD) [Posttest]
EG (multidisciplinary) [CT]	10 (0.21)	17 (0.2)**
CG (constructionist) [CT]	9 (0.18)	13 (0.31)
EG (multidisciplinary) [MT]	13 (0.12)	15 (0.28)**
CG (constructionist) [MT]	11 (0.13)	15 (0.34)**

Note. *CT = Computational thinking; MT = Mathematical thinking. **p < 0.05.

In relation to the comparison of the type of thinking assessed in the students assigned to the trainee teachers, minuscule differences were obtained, which highlighted the intergroup stability between the computational thinking of the students located in the multidisciplinary approach classrooms and those located in the constructionist approach classrooms ($t_{(911)}$ = 1,34; Diff. = 0,12; p >.05). However, differences were present in the post-test evaluation, showing benefits in the experimental group by an average of 2.31 points ($t_{(912)}$ = 1,34; p <.05). On the other hand, differences were found in the type of mathematical thinking, which were not significant in the pretest evaluation ($t_{(903)}$ = 0,98; Diff. = 11,01; p >.05). On the other hand, the differences were not significant in the post-test assessment of mathematical thinking ($t_{(901)}$ = 0,95; Diff. = 1,23; p >.05). In this sense, the individual group comparison also corroborated these characteristics in mathematical thinking (table 3). It should be noted that significant differences were also found in the experimental group in mathematical thinking (multidisciplinary approach) with a difference of 7 points (table 3). However, in the control group the difference was not significant. The intra-group comparison of mathematical thinking scores showed significant differences for the experimental group with two points on average and for the control group with four points.

As for computational thinking, this has been very flexible but at the same time long-lasting in terms of its maturity in its development in the classroom. Flexibility has been evidenced in the multidisciplinary didactic approach with the contents covered by the Project aimed at learning systems at a basic level. Evidence has shown that students have learned more practically, in turn, more creatively [15, 17, 18]. Here it should be noted that abstraction and pattern recognition skills have a certain complexity, which draws attention to the prior knowledge that school students should have acquired in and outside the classroom. While it is true that evidence shows that interaction with others often feeds knowledge about the domain of participatory technology [16, 18], it is necessary to understand that feedback is important as it has already happened in this STEAM experience in the ability of teachers to structure paired or multiple content: art-mathematics, mathematics-social-personal-science and technology On the differences found in mathematical thinking, there is still evidence to be verified, as it developed slowly and with low to moderate scores when comparing performance in both groups. The score improvement in the control group has not allowed us to disentangle with full confidence whether the constructionist approach in which the subjects in the control group developed can match the effects of the multidisciplinary approach implemented with STEAM in the experimental group. Even so, it is important to understand that being placed in cooperative learning modalities in verbal interaction experiences, the application of free creative activities, and the search for group solutions has triggered skills that allowed overcoming the low level with which school students started, as has been similarly evidenced in other studies [6, 16]. Multidisciplinary teaching did develop alongside the knowledge embedded in the cognition of schoolchildren.

3.1 Longitudinal measures: experimental group

A particular analysis of the variables involved in the study allowed us to glimpse some progress results obtained in each month of development of the experience (figure 2). Regarding the scores in the multidisciplinary teaching type (MULTEP-R), scores were found with ranges from 34 to 55 in the first six months of its development, in contrast to the self-perception they showed about their initial performance. Scores close to the high range of the teaching profile on the scale (35-55) stand out, which explains a positive perception of the practitioners as opposed to what they knew how to perform or execute as a multidisciplinary strategy in STEAM. This explains that the preparation of the teachers was specialized according to the demands of their own classrooms, in other words, while the students had to learn with certain skills and requirements, the practicing teachers adapted their techniques to integrate the contents and tasks of the curriculum in the STEAM proposal with the didactic and integrative project to the contextual characteristics of their students [10, 15, 22]. Current results have found greater versatility in the creative capacity of their students when the educational approach is open and voluntary, as it offers better possibilities for collaborative and evaluative participation [18, 20]. In that sense, teachers with better multidisciplinary adaptive practice of their strategies achieved greater effectiveness with their students compared to those who followed constructionist patterns in the classroom, which are already traditionalist for Peruvian basic education.

Regarding their self-perception, in the remaining months, the trainee teachers demonstrated scores very close to 65 on the Multidisciplinary Teaching Scale, however, not very high scores were obtained with respect to the total range of the proposed rubric: 70-75. The application of the approach has been differentiated from the scores obtained in the teachers' self-perception of their own application in this section (in relation to the data obtained by TPC-S). Although, it should be taken into account that the highest self-perception score that could have been obtained in the scale was 60, which shows a higher perception of these subjects about their performance measured by a scale, as distinguished from what they did learn to do by applying multidisciplinary strategies or methods based on STEAM. However, the growth in their teaching profile is noticeable if the skills developed during the experience are taken into account, as these could be verified by procedural activities assessed by the rubric.

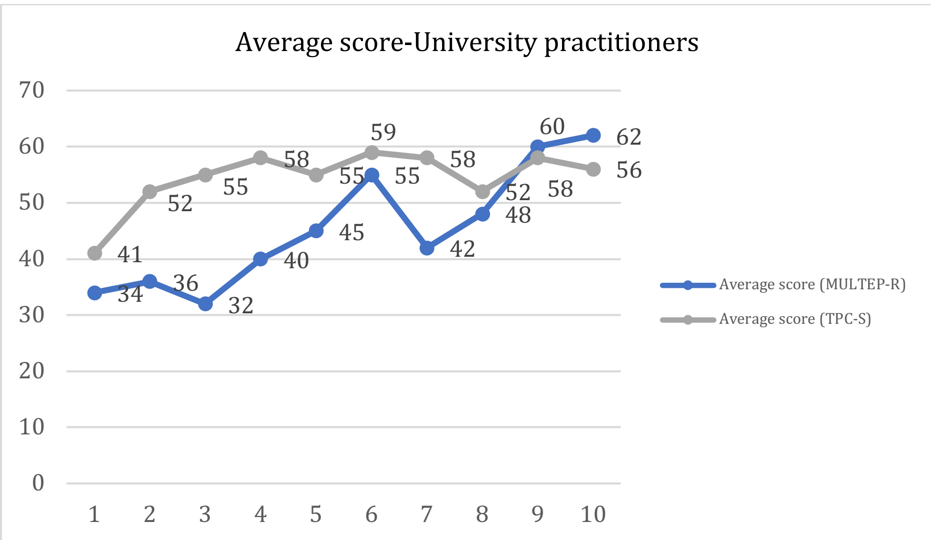


Figure 2: Averages and ratings of the multidisciplinary profile and self-perception of STEAM teaching (experimental group).

The specific analysis of the school pupils involved in the school group allowed more precise data to be obtained for the computational and mathematical thinking tasks (figure 3). Ranges of two to four minutes of development and four to five minutes of development were obtained in computational thinking and mathematical thinking respectively. This occurred during the first six months that the students received multidisciplinary STEAM instruction, so it can be argued that the tasks became more complex between the first third month and less complex by the sixth month. However, the tasks were varied at six and eight months of development, as the results in Figure 3 show that the subjects were able to demonstrate better effectiveness in computational thinking than in mathematical thinking with respect to development time, from the seventh to the ninth month of assessment fluctuating between 2.12 and 2.30 minutes compared to 3.04 and 3.09 minutes respectively.

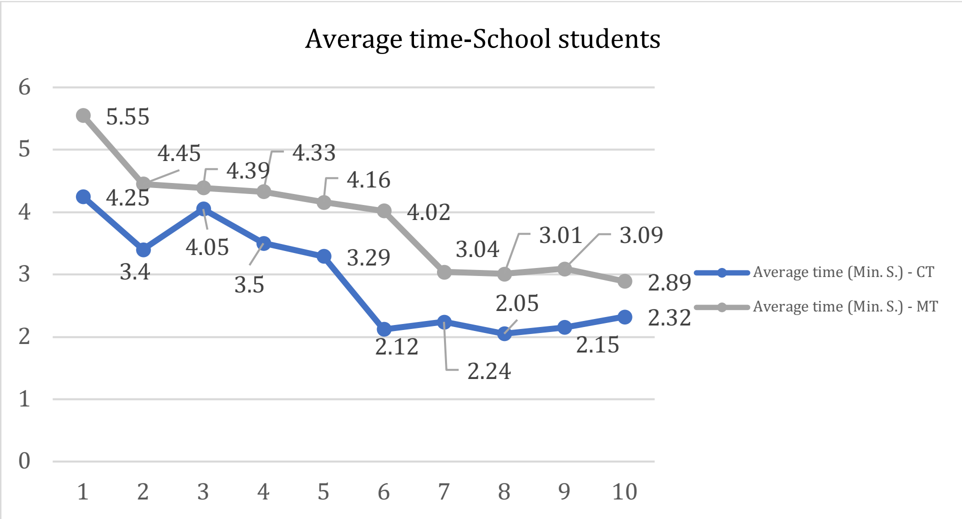
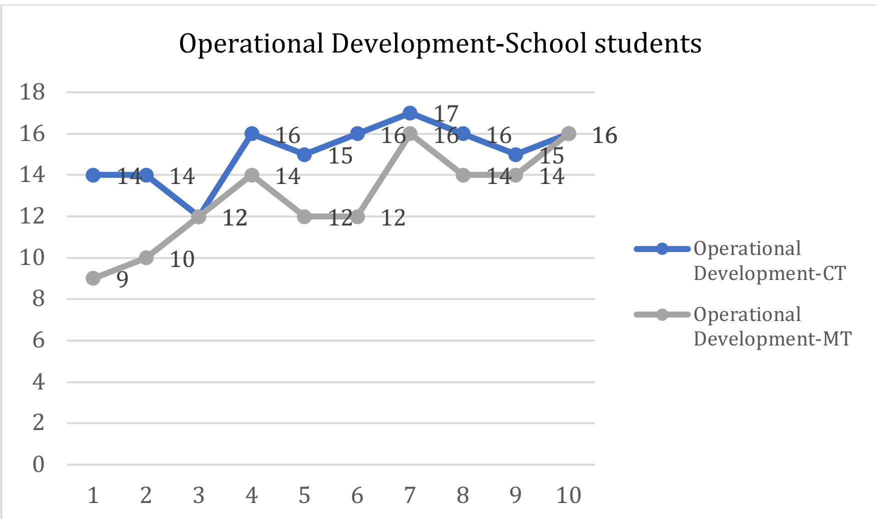


Figure 3: Developmental time averages in computational and mathematical thinking tasks.
Note. Measurements obtained from students taught by teachers in the experimental group.

The measures of operational development in the assigned tasks showed upward behavior in mathematical thinking from the first month to the fourth month of approach, in comparison to the tasks of computational behavior, remaining stable until the second month, since in the third month there was a drop from 14 to 12 points, and an upward trend between the fourth and sixth month of development (Figure 4). Computational thinking appears to have undergone changes between the fifth and seventh month of the experience, with an average of 16 points being noted in its development. The mathematical thinking was close to 20 points (high level) from the seventh month until the last month of evaluation. The developmental possibilities were more unstable in computational thinking in this last stretch: 17, 16, 15, 16. However, it should be noted that the scores in operational development were higher during the development of the experience in computational thinking as opposed to mathematical thinking.



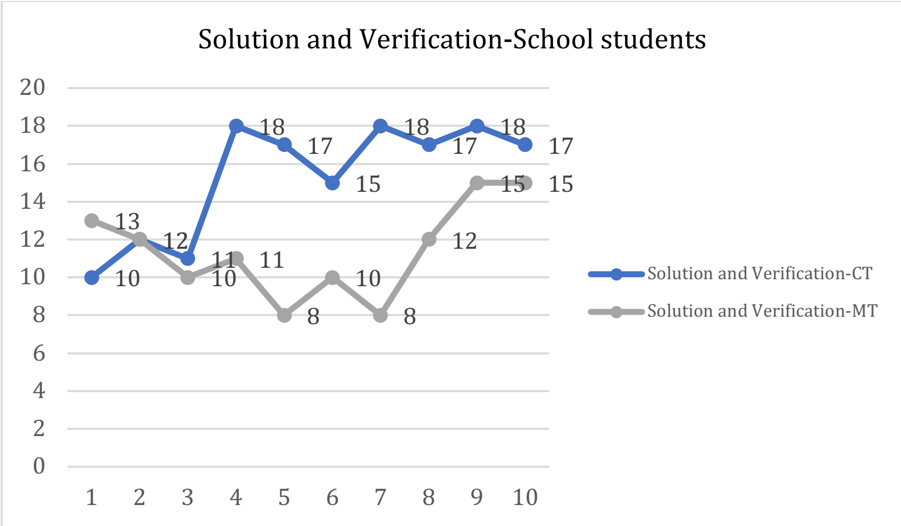


Figure 4: Averages in operational and solution development and testing of computational and mathematical thinking.
Note. Measurements obtained from students taught by teachers in the experimental group.

This change is debatable if compared to what was developed by the teacher practitioners during their multidisciplinary STEAM teaching because the application of the activities were multidisciplinary in the experimental group as opposed to those that did not integrate school curricular content. In this sense, the progress in the development of operations has been influenced by the application of activities that involved the participation of students and their collaboration in teams, and the subsequent individual work was aligned with the objectives of the programme. Students' attitudes changed as their performance progressed, each time students managed to learn to propose solutions, check them constantly as well as evaluate whether that performance was adequate. Programming as well as problem solving are more effective when subjects learn to manage solutions, spend less time solving and testing solutions in team work, although so far the evidence linked to the use of multidisciplinary didactics in the studies reviewed has not been precise in obtaining results similar to these [16, 19, 20]. Regarding the solution and verification dimension, a similar picture has been reflected as previously discussed (figure 4), considering that the scores were higher in computational thinking, presenting scores of 18 between the fifth and ninth week of development, so it can be argued that growth was more stable in this variable compared to mathematical thinking, which obtained scores mostly located in the regular level.

In view of the above, the limitations of the study are center on the collection of data and its control in relation to the number of subjects assigned to the groups compared. To a certain extent, the aim was to randomize each case more effectively, but the massification of the study prevented this task from being achieved with greater equity in the number of subjects per group. Although in this study it was possible to visualize the progressive progress of the students with valid tests for the experience, the lack of usefulness of other more reliable instruments was a possible obstacle to obtaining a greater amount of data with open resolution tasks, since what was carried out in this research sought greater topicalization of the assessment instead of finding greater generality in groups with knowledge stipulated by predetermined and hegemonic curricula.

The study contributed to proposals on profile development with competences developed in multidisciplinary activity [29, 32] and extended the perspective of innovative teaching in science [6], coupled with underlying effects on the communication, art, mathematics and computer science learning that practitioners as professional teachers had to generate in their students in their charge. As an innovative aspect, our research has focused on seeking better retributions between the student and the teacher, thus opening up the possibility for practicing teachers to sharpen their educational competences to adapt them to the characteristics of their students. The profile of education teachers has been characterized with greater composure in that teachers developing constructionist pedagogies, thus developing skills to generate and execute integrative projects as opposed to other traditional education. The development of an integrative proposal has made it possible to compensate two teaching approaches and the teaching profile, becoming more creative and flexible with multiple learning strategies.

Conclusions.

The multidisciplinary teaching profile of the trainee teachers has developed in accordance with the natural learning characteristics of school students. This profile has increased through experience in activities that corroborated the development of their skills using different sources of information and applying strategies derived from didactics that are usually thought to be opposed in constructionist or instructional education. The comparative effects between the experimental groups revealed that the STEAM Integration Project is more effective in the development of multidisciplinary teaching skills in practising teachers, compared to those who followed the current standard university scheme in Peru: classical constructionism or instructional teaching. To this is added the self-perception that teachers came to have about their own developed competences. Self-perception of multidisciplinary teaching was higher at the verified level, without neglecting the fact that teaching skills were generated in a significant way.

On the other hand, computational thinking was more progressive, complex and active to develop in the experimental group compared to the control group. The multidisciplinary teachers' perspective was more powerful when developing integrative STEAM activities in students compared to students who learned subjects individually according to the constructionist approach. It should be noted that progress in mathematical thinking was evidenced as a positive but complex factor in its development, as the methodology based on the constructionist approach (control group) matched the performance of the multidisciplinary STEAM learners (experimental group). Up to this point it could be mentioned that both approaches have the quality to develop strengthened skills and attitudes in the classroom, without yet demonstrating the difference in their effects in the classroom.

It is crucial to deepen some more specific skills in the development of mathematical thinking and computational thinking from didactics oriented to the development of integrative projects, this involves using integrated themes for the achievement of pedagogical performance in complex situations of development of the context of the participants, this includes studying the domain of teachers have in research directed to the lines of didactics and assessment of learning, as well as inclusion and personalized education. With all this, there is an opportunity to apply the STEAM approach to the skills of more experienced teachers in guiding entry-level teachers in public education. Teachers with better skills could transpose their experiences in the use of personalized strategies, thus involving research methodologies based on observation and interactive feedback in teaching practice. In this sense, it would be necessary to study the application of STEAM from the cooperation of teachers, as well as the study of the educational achievements of cooperative teacher education in educational contexts with social and economic needs with the intervention of the multidisciplinary thematic integration projects.

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