



STEAM in Primary Education. Impact on Linguistic and Mathematical Competences in a Disadvantaged Context

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This research has studied the impact of the use of STEAM (Science, Technology, Engineering, Art, and Mathematics) in education, specifically in the development of linguistic and mathematical skills. The instruments used to extract the learning results were the external evaluation tests carried out by the National Institute of Educational Evaluation INEE over a period of 4 years. The study included 242 third-level primary school students from an educational center in the city of Ceuta (Spain) located in a disadvantaged area. The objectives of the study were to describe the learning results obtained in the respective competencies according to the sex and the migratory history of the students' parents, to compare the results obtained before and during the use of STEAM and to determine if there is a correlation between the understanding of writing and problem solving. The research method was quantitative descriptive, cross-sectional and correlational. The results of the study showed that the transversal and coordinated use of STEAM improves the learning outcomes of linguistic and mathematical competence of students of the third year of Primary Education, especially speaking, oral comprehension and calculation. The results were, in general, more positive in the case of girls and students whose parents were born in Spain. The study also revealed that there is a positive correlation between reading comprehension and problem solving.

Keywords: linguistic competence, mathematical competence, Primary Education, STEAM, education

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INTRODUCTION

Background to the Study

The Organization for Economic Cooperation and Development (OECD) created, in 1997, the Program for International Student Assessment (PISA) with the aim of quantifying the learning outcomes of students from different educational systems at the international level. These results are linked to the development of skills (OECD, 2017).

Abbreviations: ICT, technology of the information and communication; INEE, national institute for educational evaluation in Spain; INTEF, National Institute of Educational Technologies and Teacher Training in Spain; LC, linguistic competence; MC, Mathematical Competence; MEyFP, Ministry of Education and Professional Training in Spain; OC, oral comprehension; OE, oral expression; OCDE, Organization for Economic Cooperation and Development; PISA, Programme for International Student Assessment; STEM, Science, Technology, Engineering and Mathematics; STEAM, Science, Technology, Engineering, Art, and Mathematics; STEAM-EDU, Science, Technology, Engineering, Art, and Mathematics in Education; WC, written comprehension; WE, written expression.

In Spain, Order ECD/65/2015 of January 2, indicates that “the OECD, in its PISA program, proposes that success in a student’s life depends on the acquisition of a wide range of competences” (2015, p.1). The person in charge of coordinating the evaluations of the Spanish educational system in collaboration with European countries is the National Institute of Educational Evaluation (INEE, 2017). This same law divides these competencies into: linguistic communication, mathematical competence and basic competences in science and technology, digital competence, learning to learn, social and civic competences, sense of initiative and entrepreneurial spirit and, finally, awareness and cultural expressions.

This research focuses on the first two linguistics and mathematics. The INEE assesses linguistic competence through four aspects: oral comprehension (OC), written comprehension (WC), oral expression (OE), and written expression (WE), with reading being the axis for the development of all areas. In this research, there is a large percentage of students with an immigrant background and who use a mother tongue other than the local language in their daily lives, finding disadvantages that affect development and understanding in all primary school subjects (Haramija, 2021). Among them, mathematical competence (MC), applying skills and skills in the use of numbers and operations, the magnitudes, measures and shapes of the environment. INEE has a special focus on calculus evaluation and problem resolution.

Organic Law 8/2013 of December 9, for the improvement of educational quality (LOMCE), in its art. 20.3 (in force during the completion of this study), establishes an assessment, of a diagnostic nature, in the third year of Primary Education in the linguistic and mathematical competences. The objective of this evaluation is to offer data and information to the educational community. These data are provided to educational centers and allow the analysis of weaknesses, threats, strengths and opportunities, taking into account the characteristics of their sociocultural environment and activating improvement mechanisms to promote optimal development of key competences among students. In addition, they allow to check the degree of development of linguistic and mathematical competences, both internally, among students from the same center and according to their characteristics, and externally, with students from other centers.

The low results obtained in these external evaluation tests by 3rd level Primary students in a public Center for Early Childhood and Primary Education (CEIP) in the city of Ceuta (Spain), in 2015, led the school to propose, in the framework of the provisions of article 18.4 of the LOMCE, the incorporation of a new subject of free configuration, based on STEAM-EDU (science, technology, engineering, arts, and mathematics in education). STEAM emerged in the last decade (Lin and Tsai, 2021) and it is a methodology that is being the object of great interest in different learning experiences (Bush et al., 2020).

This new subject, called “Digital Culture” and taught throughout the Primary Education stage, has as its axis the use of STEAM-EDU, it also integrates transversally contents from the area of Spanish language and literature and the area of mathematics. Influenced by the development of digital devices

and the rapid pace with which electronic innovations of all kinds are transferred to everyday life, the subject “is marking a new era in the application of innovative and motivating teaching and learning processes” (Hinojo et al., 2020, p.1). Its content blocks revolve mainly around computational thinking (programming and robotics) and multisensory technologies (creation of virtual worlds and video games, 3D printing or augmented reality) due to its multiple possibilities to address content from all areas and in different ages, due to its transdisciplinary nature, since “it implies merging disciplines beyond their disciplinary limits” (Wu et al., 2021, p.139).

Although the subject has its own curricular elements, these are complemented, in a coordinated way with the level teams, with content from the core areas, given its transversality with linguistic competence and its relationship with problem solving (Condori and Sosa, 2019), while developing digital competence. Its purpose is twofold: on the one hand, to increase the motivation of students for learning in a disadvantaged context, where Spanish is used as a second language by the majority of students and, on the other, to contribute to the improvement of linguistic competences (expression oral, written expression, oral comprehension and written comprehension) and mathematics (calculation and problem solving) through ICT.

This research, after 3 years applying STEAM-EDU in the area of Digital Culture of the educational center, analyzes whether there has been variation in the evaluation results of the tests carried out by the INEE in the students of 3rd grade of Primary Education, specifically in terms of relative to linguistic and mathematical competence, and if there is any correlation between some of the components of these competences.

A Summary of the Existing Literature

The emergence of electronic devices and their use, both inside and outside the school in the Primary Education stage, is modifying the way of learning, increasing access to information and modifying the type of interaction with texts, in reading and in writing (Moreno et al., 2021). In addition, students of all levels have difficulties in solving mathematical problems that require comprehension and reading (Özcan and Doğan, 2018). The aids offered by information and communication technologies allow the establishment of innovative methodological strategies that improve the motivation and adaptation of students (Demirkiran and TansuHocanin, 2021), taking into account the characteristics of each educational center.

Information and Communication Technology in Disadvantaged Environments

Today’s society shows a diversity (gender, cultural, religious, economic...) that is transferred to the classrooms, where students are equally different. In recent years, the number of immigrant students in educational centers has increased (Minister of Education and Vocational Training, 2019) and they find it necessary to provide an adequate response to this diversity. However, Spanish schools do not seem to be prepared to face this reality and offer an equitable education adapted to the new demands (Caballero, 2010). The use of ICT can favor equal opportunities in the teaching-learning process, offering

a more inclusive and intercultural training (Garrote et al., 2018). Educational centers must face the challenges of preparing competent citizens for the future and ICTs are useful tools to combat school failure, attend to diversity, promote reading and promote inclusion (Ramos et al., 2020; Vázquez et al., 2020). The use of ICT is positively correlated with socially recognized professional activities and the perception of better salaries in the future (Karpiński et al., 2021).

Salmerón and Delgado, affirm that “in the digital age, the introduction of digital technologies in classrooms is a necessary and imperative reality” (2019, p.2), although its excessive use can have adverse consequences (Vázquez et al., 2020). Social changes and technological advances in the 21st century pose changes in teaching and learning models and the need to incorporate new methodologies that enhance creativity, the ability to solve problems and the development of new digital skills in students (Casado and Checa, 2020; Ruíz et al., 2020). ICTs stimulate positive responses in students and favor their attention to STEM areas (Toma and Greca, 2018), especially when they work in a transversal and integrated way at the curricular level (Kim and Kim, 2018). The acquisition of competencies is based on a global approach, generating a direct link with the achievement of STEM skills (Ferrada et al., 2020, p.22–2).

The benefits of studying from the mother tongue and from the first years of schooling show better results in PISA. It is necessary to encourage support, from an early age, to those most disadvantaged students and groups (Pholphirul, 2017). Furthermore, “school segregation by socioeconomic background is a characteristic of most educational systems and has a negative impact on the educational results of poor children” (Prieto et al., 2020, p. 1). STEAM disciplines in education also contribute to reducing the gender gap in professional fields of science and technology, so that women participate in equal opportunities in all fields of science (Guenaga and Fernández, 2020; Kijima and Sun, 2020). Similarly, “STEAM education can encourage primary school students to reflect on scientific reasoning and critical thinking” (Bassachs et al., 2020, p. 10). This methodology, with the help of ICT, influences the development of oral expression and comprehension, in addition to the teaching process of mathematical analysis (Botuzova, 2020) and is a powerful didactic tool that involves children in active work, develops their cognitive interest, promotes better learning and enhances the effectiveness of learning (Lavrenova et al., 2020) presenting an innovative way to improve the teaching and learning of mathematics (Makonye, 2020). Therefore, “current students need meaningful and personalized learning according to their particular characteristics and that allows them to develop successfully in the new digital society in which they find themselves” (Sola et al., 2020, p. 19).

STEAM in Education

In the educational field, ICT are making way in recent years to STEAM-EDU, whose first scientific texts in education date back to 2006, although its evolution has not been progressive, highlighting the growing number of productions from 2016 to 2020 “It is a relatively new construction in the field of education and is referred to as a movement, reflecting the

increased interest in pedagogical approaches that can bring promise for innovation and society” (Colucci-Gray et al., 2019, p. 1). With STEAM, we refer to the integration of the arts (A) and creativity in classical STEM education in the field of science, technology, engineering and mathematics, for its acronym in English (Conradty and Bogner, 2020), in it, students acquire programming skills that can be transferred to other subjects and contribute to the development of skills such as reading comprehension or mathematics (Kazakoff et al., 2012), being the central axis on which this research work is concerned.

There is controversy among STEAM experts, in the way that it should be implemented in the educational system and in the schools themselves. On the one hand, there are the experts who recommend that it be developed in a transversal way from all areas of the curriculum, allowing teachers to present their integrated lessons, while students learn by doing (Webb and LoFaro, 2020), they also consider that it is impossible for a single person can teach STEAM transversally through a subject, since they do not have knowledge in other fields of the curriculum (Lu and Ma, 2019). On the contrary, there are those who are in favor of establishing an area within the curriculum, to ensure a common methodological line among the students, especially when there is little ICT training for teachers in the faculty, in which a specific subject is included, such as “Teach programming” and not understand it as a “tailor’s drawer” subject (Llorens et al., 2017, p.8).

STEAM areas offer multidisciplinary, interdisciplinary and transdisciplinary approaches, suitable for achieving learning outcomes (De la Garza, 2019). In this project, the reference center bases its methodology mainly on computational thinking, “which is acquiring great importance due to the evolution of new technologies, thus creating a global trend that considers classroom programming as a fundamental activity of the present and of the future” (Álvarez, 2017, p. 45), in addition, “it is currently considered one of the most demanded competences and, hence, its approach in the educational context” (Roig and Moreno, 2020, p. 1).

Computational Thinking and Multisensory Technologies

Although STEAM encompasses multiple disciplines to be incorporated into the school as a learning strategy, the reference educational center opts for two in the primary stage. First, computational thinking and robotics, and second, multisensory technologies.

Such is the boom that this type of innovative methodology is having, that the Ministry of Education and Professional Training (MEyFP), through the National Institute of Educational Technologies and Teacher Training (INTEF), is developing projects in collaboration with the different Spanish autonomous communities and cities, creating a school of computational thought, whose “objective of the school is to offer open educational resources and training that help Spanish teachers to incorporate this skill into their teaching practice through programming and robotics activities” (Minister of Education and Vocational Training, 2018). There are several autonomous communities in the Spanish territory, such as Andalusia and

Navarra, that integrate a specific area of computational and robotics thinking in Primary in their curriculum, however, in others such as Ceuta or Cantabria, they do not have this subject. According to Aula Planeta (2015), the objective is to give students a correct and responsible use of technological tools and the Internet and take advantage of all the options that ICT provides them in their learning, collaboration, discussion, collaborative work and meaningful and experimental learning.

Computational thinking is "supported by numerous studies that demonstrate the positive effects in relation to creativity and the ability to solve problems, these skills being necessary for individuals to face the challenges of the 21st century" (Casado and Checa, 2020, p.51). STEAM learning in general, and computational thinking in particular, are being integrated from the infant and Primary Education stages in educational centers, although unevenly (INTEF, 2019), because they provide enriching learning experiences and develop skills in solving problems that are accessible to students (Mengmeng et al., 2019). In addition, makerspaces, understood as spaces to promote creativity and collaborative learning through ICT (Freundt, 2019), causes students to experiment, plan, discuss, reflect... favoring learning by projects and discovery, attending to the diversity with significant learning that increases the motivation and participation of the students, facilitating the acquisition of content and knowledge in a gamified and playful way (Suarez et al., 2018). Computational thinking, given its interdisciplinary nature, allows one to learn other skills and content while programming and coding, being a language based on a set of rules and regulations in the form of blocks, for primary school students who report on the execution that a student must carry out. Program (Miller, 2019), is here the benefits it brings in the linguistic field, in reading and reading comprehension and as a consequence in solving mathematical problems (Miller, 2019; Molina et al., 2020).

Second, multisensory or immersive technologies, those in which students can interact with machines and enter, such as virtual reality, augmented reality, 3D printing, virtual excursions, or video game simulations, have an emerging role. in education and a particular potential to support based methodologies STEAM-EDU, in addition, stimulate the attention networks of the students, provoking greater curiosity and motivation in more abstract contents in the first educational stages, which affects the participation and the learning results of the students, being one of the aids that better they can be incorporated successfully to improve teaching (Taljaard, 2016; Demirkiran and TansuHocanin, 2021).

These two axes support the knowledge that students must have in their future insertion into the world of work, because the world economic sector is changing, driven by the advancement of technologies in the industries that are making machines replace humans, so it is convenient to acquire new skills in these disciplines (Anito and Morales, 2019). The knowledge of these STEAM resources, applied transversely as contents of the different areas of the curriculum, need time and experience to be considered as a "totally transdisciplinary curriculum in educational centers" (Wu et al., 2021, p. 159), mainly the problem is the lack of teacher training that implement teaching activities

focused on the practice of design and research competencies, such as robotics (Anisimova et al., 2020). For this, it is important to know the theoretical framework that supports any STEAM project, to specify solid guidelines for science, educators and teachers in charge of planning a STEAM educational plan at school and thus be able to teach it (Chu et al., 2018).

These STEAM disciplines allow students to become familiar with the digital world in which we live, communicate in a ubiquitous way through cooperative work and interact with virtual worlds and intelligent robots, achieving an active role for students through meaningful learning. In addition, it transversally generates knowledge and skills in other areas of the curriculum and, consequently, in the key competences, the object of study in this work.

OBJECTIVES

The purpose of the study is to analyze the impact of STEAM-EDU on the development of linguistic and mathematical competences, through the learning results obtained by third-year students of Primary Education, with a disadvantaged context, in the INEE tests. This purpose is specified in the following objectives:

1. Describe the evolution of the learning outcomes in the linguistic competence of third-year Primary Education students, in the INEE tests, during the STEAM-EDU application and, according to the sex and immigration history of their parents.
2. Describe the evolution of the learning results in the mathematical competence of third year Primary Education students, in the INEE tests, during the application of STEAM-EDU and, according to the sex and immigration history of their parents.
3. Compare the learning results obtained in linguistic and mathematical competences before and during the use of STEAM-EDU.
4. Determine if there is a correlation between written comprehension and problem solving.

METHODOLOGY

The study is a quantitative research that obeys a descriptive and correlational quasi-experimental design (Cohen et al., 2007), since it describes in a systematic, objective and verifiable way,

TABLE 1 | Distribution of participants by years.

	Without STEAM	STEAM	STEAM	STEAM
	Year 2015	Year 2016	Year 2017	Year 2018
	<i>n</i>	<i>n</i>	<i>n</i>	<i>n</i>
<i>Linguistic competence</i>	46	60	43	60
<i>Mathematical competence</i>	45	60	53	64

TABLE 2 | Characterization of participants.

	Without STEAM	STEAM	STEAM	STEAM
	2015 %	2016 %	2017 %	2018 %
Sex				
Man	52.00	50.00	38.33	37.93
Woman	48.00	50.00	61.67	62.07
Total	100.00	100.00	100.00	100.00
Use of technological and cultural resources in households				
Little or nothing	22.60	38.98	21.43	30.00
Sometimes	41.90	27.12	33.33	18.33
Frequently	32.30	28.82	42.86	43.33
Daily	3.20	5.08	2.38	8.34
Total	100.00	100.00	100.00	100.00
Educational level of the families				
No studies	52.40	51.92	46.16	55.77
Compulsory basic education	35.70	25.00	23.08	25.00
Secondary education	9.50	15.38	15.38	13.46
Higher education	2.40	7.70	15.38	5.77
Total	100.00	100.00	100.00	100.00
Parents' immigration history				
None of the parents born in Spain	17.90	16.67	29.27	16.07
At least one, born in Spain	59.00	66.66	53.66	53.57
The two parents born in Spain	23.10	16.67	17.07	30.36
Total	100.00	100.00	100.00	100.00

facts and results of an educational reality and analyzes possible correlations between variables. It is supported by a cross-sectional and comparative method that allows “to establish distinctions between events and variables that are repetitive in

the realities studied” (Abreu, 2015, p.209). In our case, the learning results obtained during 4 years (2015–2018) by students in the third year of Primary Education in the external evaluation tests for the preparation of the INEE reports are taken as a reference. Specifically, the results corresponding to linguistic and mathematical competence. The 2015 results are prior to the incorporation of STEAM-EDU, while the 2016–2018 period corresponds to the stage in which this methodology is adopted.

Research Context and Participants

The study is carried out in a CEIP located in the autonomous city of Ceuta (Spain). The center is located in a suburb neighborhood a few meters from the border with Morocco. It is a disadvantaged area, with a high rate of unemployment and job instability, inhabited almost entirely by people from the neighboring country and of Islamic religion. Most of the parents have not completed compulsory education and there are few technological and cultural resources in the home.

The educational center in which the research is carried out has three lines and is attended by 480 students. The incorporation of STEAM-EDU to the curricular proposal, within the area of free configuration of Digital Culture, is carried out as a proposal to improve skills in linguistic and mathematical competence and facilitate the use of technological resources in the learning process. This area is implemented for all courses and levels of the Primary Education stage. It is developed in coordination with the tutors of the different levels, to reinforce the contents of the area of Spanish language and literature and mathematics, through ICT.

A total of 242 students belonging to the third level of Primary Education participated in the study for 4 years. Of these, 209 have taken the assessment test for linguistic competence and 222 the assessment test for mathematical competence. **Table 1** shows the distribution of students (n) by years.

Next, in **Table 2**, the percentages of student participation (%) in standardized tests are presented, in the period covered by

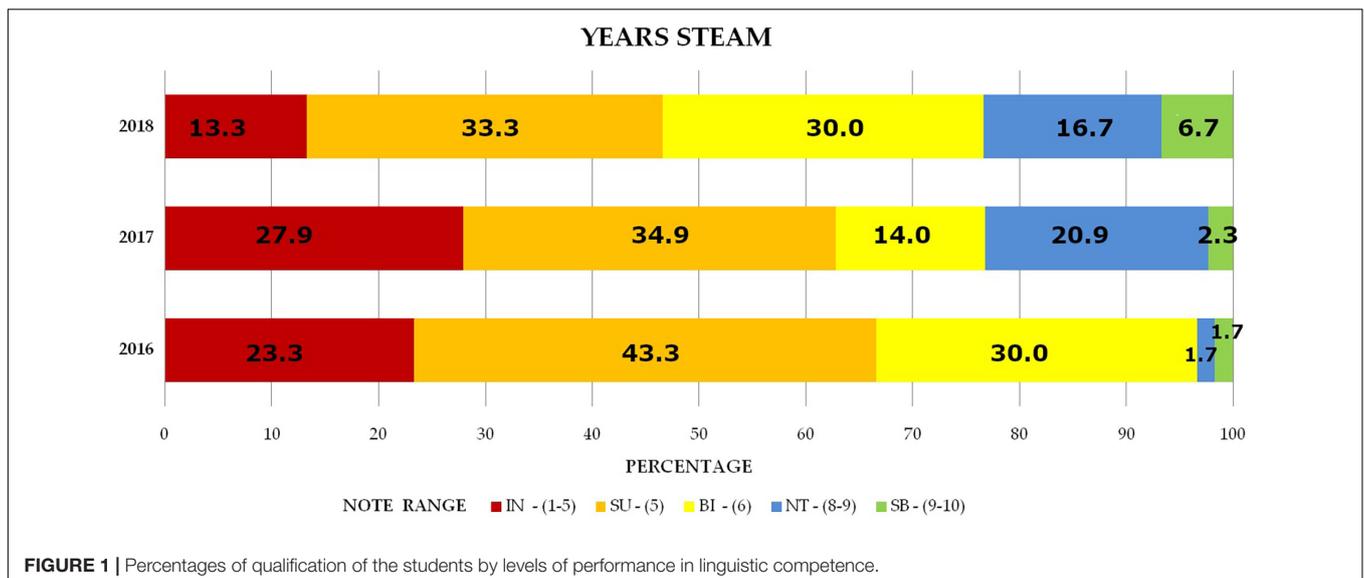


FIGURE 1 | Percentages of qualification of the students by levels of performance in linguistic competence.

TABLE 3 | Linguistic competence by years.

Years STEAM	\bar{x}	σ
2016	5.49	1.20
2017	5.52	1.80
2018	5.98	1.86

our study, according to sex, use of technological and cultural resources in homes, level of studies in parents’ families and immigration history.

Information Collection and Analysis

The evaluation of the linguistic and mathematical competencies of third-level students of Primary Education has been carried out by applying the standardized tests designed by the National Institute of Educational Evaluation (INEE), so they are valid and reliable instruments (available at the INEE portal). The results for carrying out this work have been provided by the educational center where the study is carried out, through the INEE, and correspond to the years 2015, 2016, 2017, and 2018, respecting the agreements and ethical aspects of this investigation. During the information collection and analysis process, the anonymity of the participants has been respected and the confidentiality of the data provided has been guaranteed (McMillan and Schumacher, 2011).

The data obtained have been subjected to a descriptive analysis (arithmetic mean and standard deviation) to respond to the first three objectives of the study and to a correlational analysis, to cover objective 4. In the latter case, we analyze the possible correlation between written comprehension and problem solving because they are the variables that present the lowest scores in each of the competences analyzed. For this we use Pearson’s Correlation Coefficient, since they are parametric variables whose scores follow a normal distribution. The analysis of the collected data has been carried out using the SPSSv.25 software.

RESULTS

Next, we represent the results obtained, in relation to each of the objectives defined in the study.

Results Related to Objective 1

Describe the evolution of the learning results in the linguistic competence of students of the third year of Primary Education, in the INEE tests, during the application of STEAM-EDU and according to sex and immigration history of their parents.

We present the results of this first objective, showing in a generic way, the global qualification percentages obtained in linguistic competence (Figure 1), as well as the means (\bar{x}) and standard deviations (σ) in Table 3, in each one of the years, in which STEAM has been used.

According to the data shown, a decrease of 10 points is observed in the percentage of students who obtain the “insufficient” qualification, going from 23.3%, in 2016 to 13.3%, in 2018. In the case of the “remarkable” qualification, the percentage increases significantly, with a difference of 15 points, since it goes from 1.7 (2016) to 16.7 (2018) and, with an even greater difference compared to 2017 (20.9). These data contribute to increasing the values of the global means for years, which rise from 5.49 in 2016 to 5.98 in 2018. The standard deviation also increases, which shows a greater dispersion of the results in 2018.

In Table 4, we have presented the means and standard deviations for the period as a whole (2016–2018), corresponding to linguistic competence (LC) and its four skills: oral expression (OE), written expression (WE), oral comprehension (OC) and written comprehension (WC), and differentiating according to the sex and immigration history of their parents.

The global mean for the 3 years is $\bar{x} = 5.68$. The highest mean score corresponds to OE ($\bar{x} = 6.20$) and the lowest to WC ($\bar{x} = 5.01$). Girls obtain better mean scores than boys in linguistic competence, with a difference of 0.22 points, and in all its dimensions, while presenting a lower standard deviation. Both sexes obtain their best results in OE, surpassing an average of 6 points and the worst in WC, especially boys, whose average does not reach 5 points ($\bar{x} = 4.84$).

If we focus on the immigration history of their parents, students with both parents born in Spain, accumulate the highest average values, both in the LC, in general, and in its components, in all cases above 6, except in two (WE and WC). On the contrary, the students whose parents were not born in Spain, present the lowest average values of the LC and its components. The OE is the component of linguistic competence that presents the highest values of the mean and the WC is the one that brings together the

TABLE 4 | Comparison of results in LC, its components, sex and immigration history.

Items years 2016–2017–2018	LC		OE		WE		OC		WC	
	\bar{x}	σ								
Linguistic competence	5.68	1.64	6.20	1.67	5.59	1.65	5.92	1.66	5.01	1.68
Sex										
Boys	5.55	1.72	6.09	1.78	5.47	1.69	5.80	1.78	4.84*	1.71
Girls	5.77	1.59	6.28	1.60	5.67	1.62	6.00	1.57	5.12	1.67
Immigration background										
No father born in Spain	5.48	1.44	5.97	1.48	5.48	1.37	5.72	1.58	4.76*	1.58
A father born in Spain	5.64	1.64	6.17	1.66	5.51	1.70	5.89	1.60	4.98*	1.70
The two parents born in Spain	6.03	1.84	6.56	1.89	5.94	1.77	6.23	1.93	5.37	1.87

*Number of participants evaluated. 163 = Linguistic Competence, for sex, 67 = boys, 96 = girls. For immigration history, 33 = no parent born in Spain, 100 = one parent born in Spain, 30 = both parents born in Spain. *Score < 5.

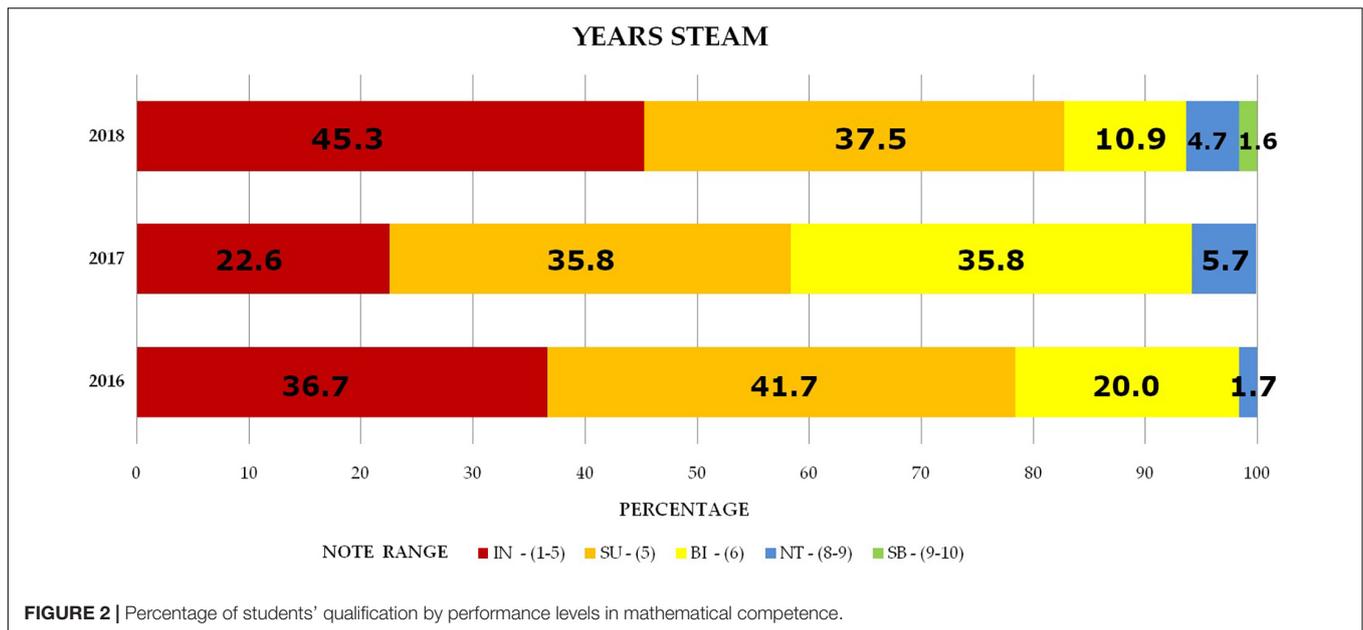


FIGURE 2 | Percentage of students' qualification by performance levels in mathematical competence.

lowest arithmetic means, regardless of whether the students have an immigration background or not.

Results Related to Objective 2

Describe the evolution of the learning results in the mathematical competence of students in the third year of Primary Education, in the INEE tests, during the application of STEAM-EDU and according to sex and immigration history of their parents.

In this case, the procedure followed to present the results was the same as that followed in objective 1 (Figure 2). In addition, we show in a generic way in Table 5, the global qualification percentages obtained in linguistic competence, as well as the means (\bar{x}) and standard deviations (σ), in each of the years in which the methodology has been used, based on STEAM.

According to the data shown in Figure 2, the percentage of students who obtain the “insufficient” qualification, although it decreased from 2016 to 2017, has increased significantly in 2018. The best percentages of qualifications correspond to 2017, where the percentage of Students with a “good” grade increased by just over 15 points, as did the number of outstanding students, although to a lesser extent and the percentage of failures decreased. However, 2018 is the only year in which there are students who have achieved “excellent” (1.6%). These data have placed the global average in 2018 below 5 points, lower than the other years. Thus, a positive and increasing linear progression is not observed in the global means.

Next, in Table 6, we show the means and standard deviations of the entire period as a whole (2016–2018), corresponding to mathematical competence (MC) and its two skills: calculation and problem solving, differentiating based on the variables sex and immigration history of their parents.

The global mean values for the period 2016–2018, in which STEAM has been used, do not reach a value of 5 points in

MC ($\bar{x} = 4.98$), although in calculation skills it is higher than 5 ($\bar{x} = 5.22$), it is the mean in problem solving ($\bar{x} = 4.73$), which causes the general mean in MC to decrease. There is also a high dispersion of the results ($\sigma = 1.93$) in problem solving. Regarding the gender of the students, girls obtain better average scores than boys, in mathematical competence, in general (with a 0.37 point difference), in calculus and problem solving. The lowest scores of the arithmetic mean, in both sexes (less than 5), correspond to problem solving, where the highest standard deviations are also found ($\sigma = 2.07$ in boys and $\sigma = 1.81$ in girls).

According to the immigration background of the parents of the students, the highest average scores on the MC and problem solving correspond to students whose parents were both born in Spain. Only in the case of calculation, there is a tie with students who do not have a parent born in Spain. The lowest mean scores on the MC and its two components correspond to students with a parent born in Spain. Of the two evaluated components of the MC, the one with the lowest scores is problem solving, regardless of immigration history. In all cases, except in the students with both parents born in Spain, the average scores are below 5 points.

Results Related to Objective 3

Compare the learning results obtained in linguistic and mathematical competences before and during the use of STEAM-EDU.

TABLE 5 | Mathematical competence by years.

Years	\bar{x}	σ
2016	5.06	1.24
2017	5.21	1.98
2018	4.70*	1.97

*Score < 5.

TABLE 6 | Comparison of results in MC, its components, sex and immigration history.

Items	n	Mathematical Competence		Calculation		Problem Resolution	
		\bar{x}	σ	\bar{x}	σ	\bar{x}	σ
Years 2016–2017–2018	177	4.98*	1.77	5.22	1.71	4.73*	1.93
Sex							
Boys	75	4.76*	1.94	5.04	1.90	4.49*	2.07
Girls	102	5.13	1.62	5.36	1.54	4.90*	1.81
Immigration background							
No father born in Spain	33	5.02	1.53	5.30	1.55	4.74*	1.61
A father born in Spain	113	4.91*	1.87	5.18	1.80	4.65*	2.04
The two parents born in Spain	31	5.16	1.65	5.30	1.55	5.01*	1.87

*Score < 5.

TABLE 7 | Percentages of passed and failed by years in linguistic and mathematical competencies.

Items	Year 2015		Year 2016		Year 2017		Year 2018	
	n	%	n	%	n	%	n	%
	Linguistic competence							
Approved	16	34.78	46	76.70	31	72.10	52	86.67
Suspensions	30	65.22	14	23.30	12	27.90	8	13.33
Total	46	100.00	60	100.00	43	100.00	60	100.00
Mathematical competence								
Approved	10	22.22	39	63.29	41	77.36	35	54.69
Suspensions	35	77.78	22	36.71	12	22.64	29	45.31
Total	45	100.00	61	100.00	53	100.00	64	100.00

In this section we will contrast the results obtained in 2015, the year in which STEAM-EDU had not yet been adopted, with the years in which it had been incorporated into teaching in the field of Digital Culture.

According to the percentages shown in **Table 7**, a very important change in trend can be seen in both the LC and the MC. In the case of the LC, it went from 34.78% of students approved in 2015, to 76.7%, in 2016, until reaching 86.67% in 2018. The progression is really relevant and represents a decrease, equally outstanding, percentage of failures.

In the case of the MC, the percentage of approved increases with respect to 2015, going from 22.22% of approved, to surpass at least, in the rest of years, 54.69% (year 2018).

Next, we show a specific comparison for each of the competences analyzed and their components using arithmetic means and standard deviations.

Comparison of Linguistic Competence

Observing **Table 8**, the mean values achieved by the LC and its skills in 2015, we find that, in all cases, they are lower than the mean scores obtained in the 2016–2018 period in which STEAM-EDU has been used. The values of the standard deviations have decreased, in all cases, reaching equilibrium between 1.65 and 1.68, thus accumulating a larger sample around ratings with $\bar{x} > 5$.

In **Figure 3**, the positive evolution of the LC and of all its skills is shown during the 4 years, except the WC in 2017, which

presents a $\bar{x} = 4.63$ and which represents a slight decrease with respect to 2016 ($\bar{x} = 4.95$). In 2018, the best results were obtained in WC, with $\bar{x} = 5.33$, since, for the first time in 4 years, third-year students obtained a $\bar{x} > 5$ in all dimensions of the LC.

Comparison of Mathematical Competence

The mean values of the MC and its two skills, in 2015, are lower, in all cases, than the mean scores obtained in the 2016–2018 stage, as shown in **Table 9**. However, the means in the MC (4.98) and problem solving (4.73) are still below 5 points. The values of the standard deviations have also decreased, compared to 2015, in all cases, oscillating between 1.71 and 1.93 points, which indicates a lower dispersion of the results.

In **Figure 4**, it is observed that the mean of the MC (2.58), the calculation (2.79) and the problem solving (2.38) of the year 2015, increases in the years in which STEAM has been used. In 2016 and 2017, there is an upward and positive evolution in calculation ($\bar{x} > 5$) and problem solving (although with $\bar{x} < 5$). This ascent is interrupted in 2018, with a steeper decline in calculation and less pronounced in problem solving.

Results Related to Objective 4

Determine if there is a correlation between written comprehension and problem solving.

In this section, we choose the two skills with the lowest average score in each of the competencies, during the 4 years (2015 to

TABLE 8 | Arithmetic means and standard deviations of linguistic competence and its dimensions.

Items	n	LC		EO		EE		CO		CE	
		\bar{x}	σ								
Year 2015	46	2.98*	2.21	3.30*	2.28	2.59*	2.11	3.60*	2.46	2.43*	2.09
Years STEAM	163	5.68	1.64	6.20	1.67	5.59	1.65	5.92	1.66	5.01	1.68

STEAM Years = 2016, 2017, 2018. *Grade < 5.

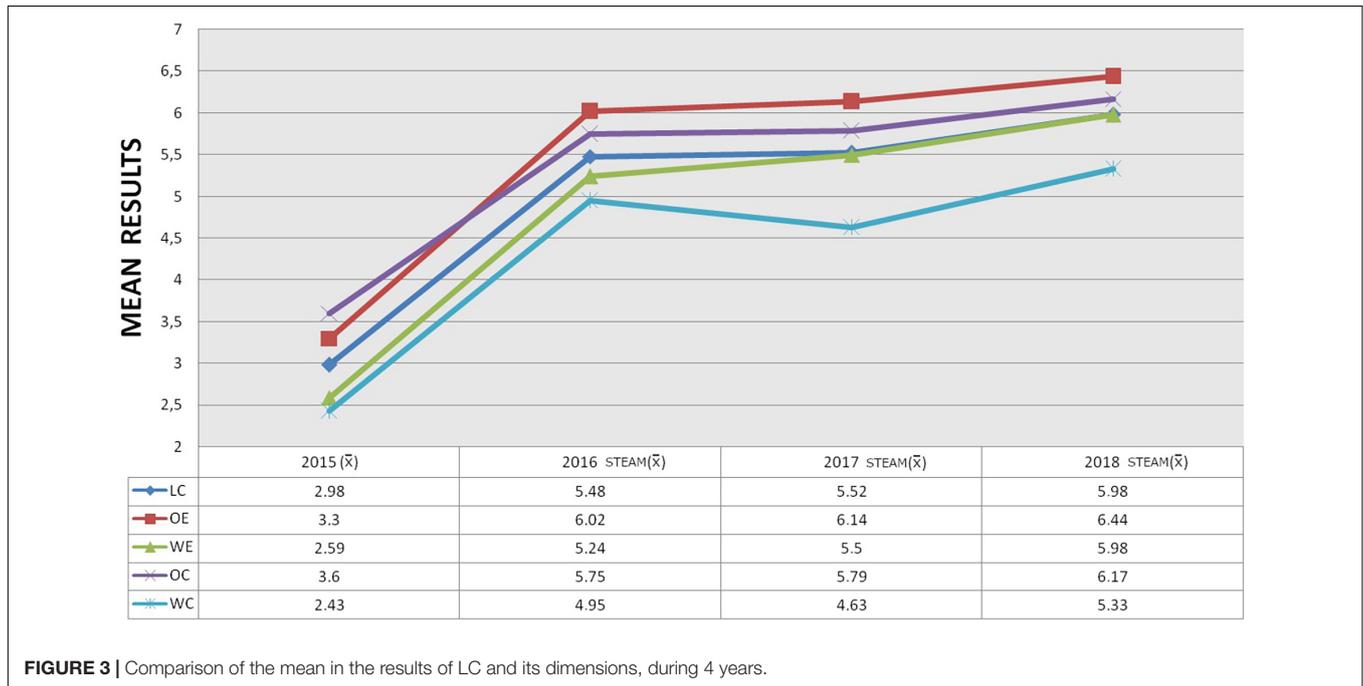


FIGURE 3 | Comparison of the mean in the results of LC and its dimensions, during 4 years.

2018), that is, written comprehension and problem solving, to determine if there is any correlation between them. To extract the results of this objective, only the 207 cases are selected, in which the students have taken the two tests during the 4 years, excluding 15 students who only took one of the two tests.

In the first place, we show in **Table 10** the arithmetic mean, which does not exceed 5 points in either of the two skills, and the standard deviations in both cases are very dispersed with values greater than 2 points.

In **Figure 5**, a high positive correlation $R^2 = 0.845$ is observed, that is, when the results improve in written comprehension, so does problem solving.

In **Table 11**, we observe the Pearson’s correlation coefficient between the two skills, with a value $r = 0.919$, according to Suárez (2011), it is considered a very high positive correlation when it exceeds the value of 0.9, establishing a directly proportional relationship, that is, when the results improve in written comprehension, so does problem solving.

DISCUSSION

Considering how prevalent ICTs are in people’s daily lives, it is unthinkable that schools cannot incorporate them into their teaching methodologies for children and adolescents, as Moreno et al. (2021) note. According to other studies (OECD, 2017; Casado and Checa, 2020; Ruíz et al., 2020), this allows us to attend to the diverse needs of students in an educational setting while at the same time preparing them for the digital working life in which we live. In schools, science and art are normally separated. However, in the context of this study, ICT can interrelate these two disciplines due to the creative resources they can generate, as suggested by Conrady and Bogner (2020); Demirkiran and TansuHocanin (2021), Hinojo et al. (2020), and Wu et al. (2021). Therefore, STEAM-EDU and a good educational use planned and structured from one specific area, have a transversal impact

TABLE 9 | Arithmetic means and standard deviations of mathematical competence and its dimensions.

Items	n	Mathematical Competence		Calculation		Problem Resolution	
		\bar{x}	σ	\bar{x}	σ	\bar{x}	σ
Year 2015	45	2.58*	2.26	2.79*	2.34	2.38*	2.23
Years STEAM	177	4.98*	1.77	5.22	1.71	4.73*	1.93

STEAM Years = 2016, 2017, 2018. *Grade < 5.

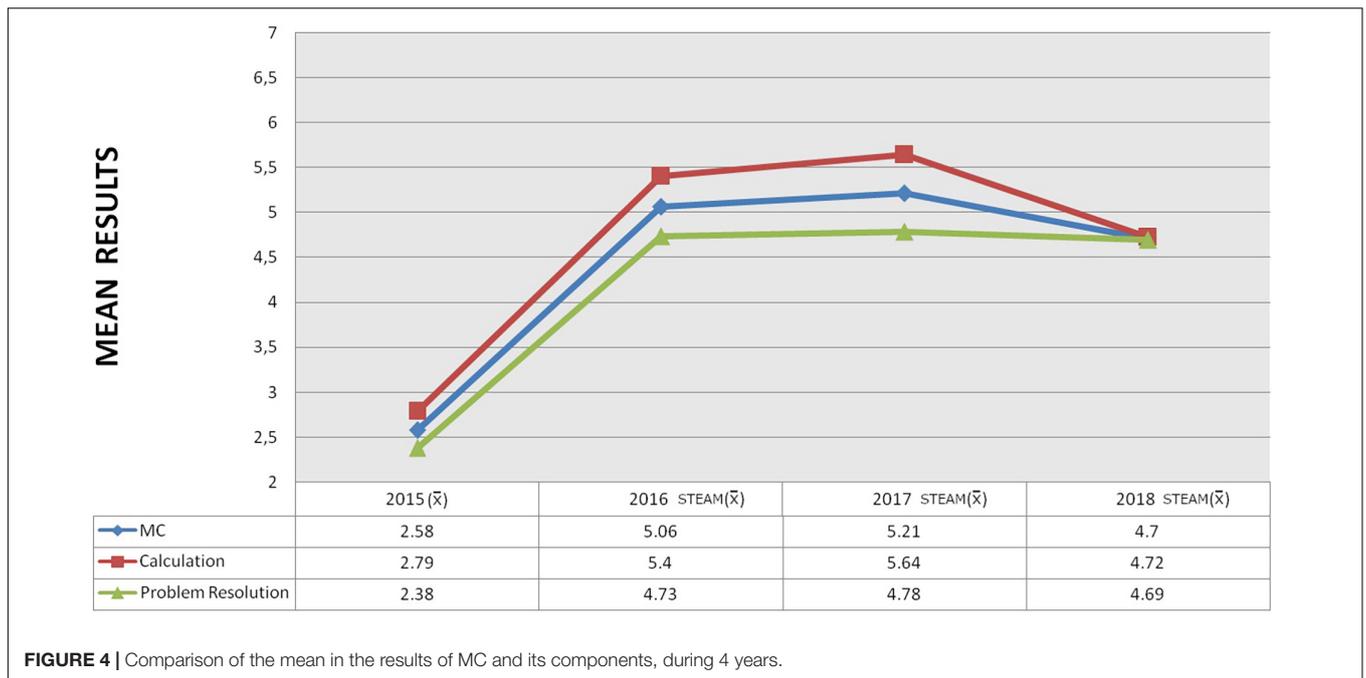


FIGURE 4 | Comparison of the mean in the results of MC and its components, during 4 years.

on other areas of the curriculum as demonstrated by Condori and Sosa (2019); Kazakoff et al. (2012), Lin and Tsai (2021), and Salmerón and Delgado (2019).

These findings show that incorporating STEAM-EDU and computational thinking within a framework improves linguistic and mathematical competence in general. These findings are congruent with those obtained by Molina et al. (2020), Miller (2019), and Vázquez et al. (2020). Although these advances above average pass rates are not very notable in quantitative terms, they occurred in a disadvantaged environment with a high proportion of immigrants, where Spanish is predominate. These data also agree with those from other research (Garrote et al., 2018; Lavrenova et al., 2020; Makonye, 2020, and Ramos et al., 2020).

There is a slight improvement of the averages on linguistic competence in the years in which the STEAM-EDU methodology is implemented in disadvantaged environments, where oral expression scores the highest, due to oral and teams work that include this type of methodology, as established by various studies (Suarez et al., 2018; Freundt, 2019; Miller, 2019; Molina et al., 2020). In addition, girls performed better than boys in all aspects of linguistic competence, however, there was a gender gap in STEAM as also postulated by Garrote et al. (2018). Pholphirul

(2017) also notes that students from families who are born in Spain show better results, that is, those who have the same linguistic support at home as used in schools do well. The same cannot be said for reading comprehension, where students with relatives with an immigration background must decipher and process new codes.

In relation to the area of mathematical competence, even if STEAM is closely tied to mathematics, results are subjective and no significant progress has been witnessed during the period when the Digital Culture area has developed. Calculus obtained better results than problem solving, these data are not in agreement with the studies by Casado and Checa (2020) and Mengmeng et al. (2019). In addition, the girls present better results than the boys, both in calculation and in problem solving, with no differences in this study in those families with and without an immigration background, therefore, STEAM-EDU attends to diversity, as Caballero also points out. (2018) and Garrote et al. (2018).

Focusing on the results obtained in the course prior to the implementation of the Digital Culture area and the subsequent ones, a clear increase in the results of both competences is observed. It is remarkable in the case of girls, for which the use of STEAM-EDU could facilitate greater visibility of women, as well as their future insertion in fields related to science and technology, thus contributing to reduce the gap currently existing in these areas, as Guenaga and Fernández (2020) and Kijima and Sun (2020) also consider.

Finally, there is a high correlation between reading comprehension and problem solving, confirming the theories of Condori and Sosa (2019) and Özcan and Doğan (2018) Özcan and Doğan (2018), according to which students with lower reading and writing comprehension have more difficulties to solve mathematical problems. However, in this context, where

TABLE 10 | Means and standard deviations in written comprehension and problem-solving skills.

Ítems	n	\bar{x}	σ
Written Comprehension	207	4.44*	2.08
Problem Resolution	207	4.35*	2.16

*Grade < 5.

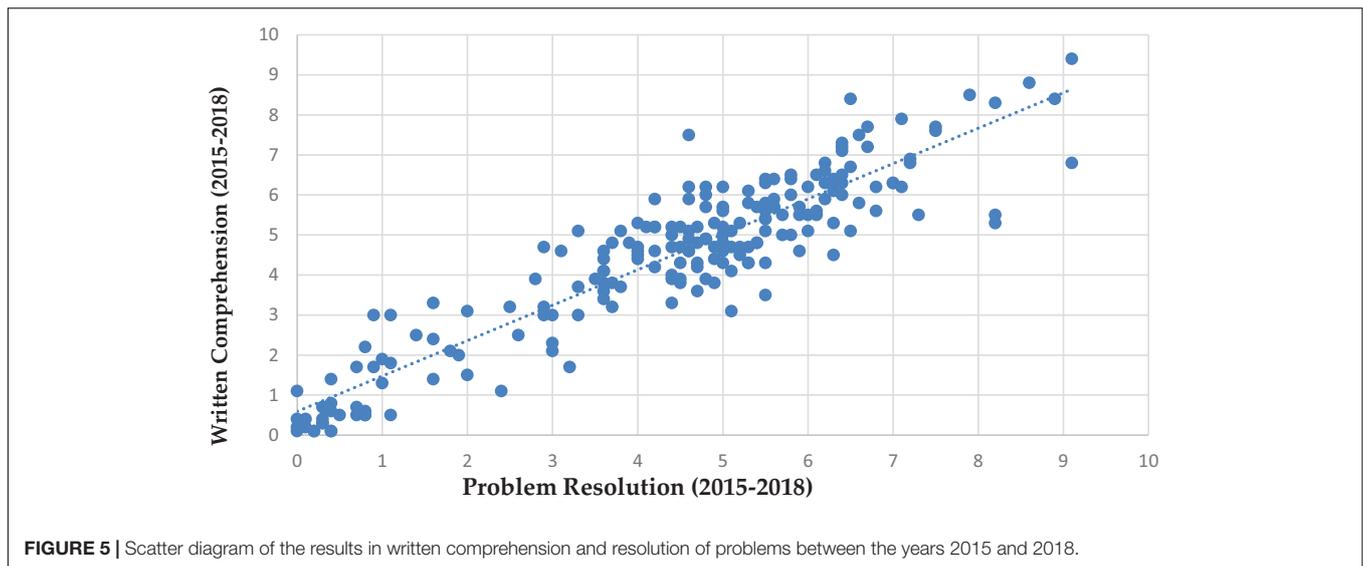


FIGURE 5 | Scatter diagram of the results in written comprehension and resolution of problems between the years 2015 and 2018.

there is a greater positive impact on linguistic competence, it stands out that in mathematical competence, the greater positive impact is on calculation and not on problem solving, where reading, discussion and reasoning should have an influence, these results are not in line with the studies by Botuzova (2020). In this specific case, given that the study is carried out in a disadvantaged environment, where Spanish is used as a second language, it would be advisable to expand and delve into other possible factors that may be hindering a more notable improvement in learning outcomes.

After the results of this study, the implementation from the earliest ages of development is recommended, as suggested by Zapata (2015) of the STEAM methodology in the educational field. This possibility could help increase performance and skills in other disciplines and contribute to the development of digital competence in students due to its transversal nature, as reported by several studies (Kim and Chulhyun, 2016; De la Garza, 2019; Webb and LoFaro, 2020; Wu et al., 2021). The MEyFP and the different regional education ministries should reflect on this and contemplate its possible inclusion in the curriculum, either transversally in the Primary Education stage or through

a specific subject, as also indicated by research (Llorens et al., 2017; Pholphirul, 2017; INTEF, 2019; Lu and Ma, 2019; Webb and LoFaro, 2020). It would be convenient to increase the coordination and digital training of teachers to integrate this type of methodology in the classroom, as pointed out by Chu et al. (2018) and Moreno et al. (2021). This stage of legislative transition, in which the Organic Law 3/2020 of December 29 has just been approved in Spain and the approval of a new curriculum is articulated, could be a propitious moment to frame this type of methodologies in early ages as also pointed out by Taljaard (2016), Chu et al. (2018), Demirkiran and TansuHocanin (2021) and Wu et al. (2021).

CONCLUSION

The results obtained in the study allow the following conclusions to be drawn:

In Relation to the First Objective

1. Employing STEAM-EDU continuously, within the framework of a free configuration subject and in a disadvantaged context, produces benefits in the learning results in the linguistic competence of third-level students of Primary Education.
2. The use of STEAM-EDU contributes to developing linguistic competence, in this order: oral expression, oral comprehension, written expression and, to a lesser extent, written comprehension.
3. STEAM-EDU has a greater impact on girls in all assessed components of language proficiency.
4. STEAM-EDU positively influences the performance of students who have a history of immigration in their parents, although their learning results in linguistic competence and in all its components are lower than those of those students who do not have a history of immigration.

TABLE 11 | Correlation between written comprehension and problem resolution.

		Written Comprehension	Problem Resolution
Written Comprehension	Pearson's correlation	1	0.919**
	Sig. (bilateral)		0.000
	n	207	207
Problem Resolution	Pearson's correlation	0.919**	1
	Sig. (bilateral)	0.000	
	n	207	207

**High positive correlation.

In Relation to the Second Objective

1. The incorporation of STEAM-EDU has a positive impact on the results in mathematical competence in all students, especially in those whose parents were born in Spain.
2. The results of the study show better learning results in calculation than in problem solving.
3. Girls perform better in calculation and problem-solving skills than boys.

In Relation to the Third Objective

1. During the years in which STEAM-EDU has been used, better results have been obtained in linguistic competence and in its skills, compared to the year in which it has not been used.
2. STEAM_EDU contributes to the development of results in mathematical competence for all students, especially in calculus. However, in problem solving, although the results improve, so far they are slightly below the approved level.
3. The results in mathematics are lower than those achieved in linguistic competence, perhaps because students discuss, debate, explain their reasons, expose in makerspaces..., and all this contributes to developing oral expression and comprehension, which is where they have been obtained best results.

In Relation to the Fourth Objective

1. There is a positive correlation between written comprehension and problem solving that allows associating that the improvement of reading comprehension also contributes to improving the competence to solve problems.

LIMITATIONS AND PROSPECTS OF THE STUDY

The study provides data of interest that show the impact of STEAM-EDU. However, the study is limited to a very specific

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school and a specific student body in a disadvantaged context. It would be interesting to expand the sample and the study contexts.

The results obtained and the conclusions invite to delve into other possible correlations and lines of research. There are several authors who highlight the motivational and innovative factor that ICTs produce in education (Colucci-Gray et al., 2019; Hinojo et al., 2020; Makonye, 2020; Demirkiran and TansuHocanin, 2021) and that can influence the development of linguistic and mathematical skills. It would therefore be advisable to carry out quasi-experimental studies, with an experimental and control group, in disadvantaged environments and analyze their impact on the learning of these or other competences. The use of in STEAM-EDU is on the rise, but research focused on it is a recent field of inquiry. It is necessary to broaden research in this field and delve into the ways of integrating it into the educational system, how to encourage and train its use among teachers and to reveal its true contribution to the educational and social inclusion of underprivileged students.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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