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STEAM projects with KIKS format for developing key competences

Proyectos STEAM con formato KIKS para el desarrollo de competencias clave

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ABSTRACT

Secondary education curricula highlight competence-based learning; although meaningful school-intervention habits have not yet been observed. The initiatives implemented have focused primarily on promoting the combined development of no more than three key competences. This article presents an international study under the Erasmus+ and H2020 programmes, for analysing the impact of the STEAM project-based learning approach with KIKS format (Kids Inspire Kids for STEAM) on the interwoven development of key competences. The sample included 267 high school students divided into 53 teams from 29 educational centres in Finland, England, Hungary, and Spain. Each team carried out several projects for no less than two academic years, by means of the following two approaches: STEAM project-based learning and KIKS. Data were collected from observations and interviews with students, teachers, and KIKS trainers. Analyses revealed that the combination of these two approaches facilitate the development of all eight key competences. The project-based learning focus essentially fostered the enhancement of the mathematical competence and in science, technology, and engineering, while KIKS format promoted literacy and multilingual competences. The remaining competences were encouraged by the combination of both approaches. It is noteworthy that prolonged participation in the programme, as it was implemented, was crucial to achieving the obtained outcomes.

RESUMEN

Los currículos de educación secundaria resaltan el aprendizaje por competencias, aunque actualmente no se observan cambios sustanciales en los hábitos de intervención en el aula. Las iniciativas implementadas se han centrado principalmente en impulsar el desarrollo conjunto de tres competencias clave como máximo. Este artículo presenta un estudio internacional bajo los programas Erasmus+ y H2020, con el objetivo de establecer relaciones entre el aprendizaje basado en proyectos STEAM con formato KIKS (Kids Inspire Kids for STEAM) y el desarrollo global de las competencias clave. La muestra incluye 267 estudiantes de secundaria distribuidos en 53 equipos de 29 centros de Finlandia, Inglaterra, Hungría y España. Cada equipo elaboró varios proyectos durante al menos dos años académicos con los siguientes enfoques de implementación: aprendizaje basado en proyectos STEAM y KIKS. Los datos se recabaron por medio de observaciones y entrevistas a estudiantes, profesores y formadores KIKS. Los análisis revelaron que la combinación de ambos enfoques facilita el desarrollo de las ocho competencias clave. El aprendizaje por proyectos favoreció esencialmente la competencia matemática y en ciencia, tecnología e ingeniería, mientras que el formato KIKS potenció las competencias en lectoescritura y multilingüe. El resto se vieron estimuladas por la combinación de ambos enfoques. Cabe destacar que la participación prolongada en el programa de implementación fue determinante en los resultados obtenidos.

KEYWORDS | PALABRAS CLAVE

Competence, project-based learning, STEAM, KIKS format, secondary education, internationalization.
Competencia, aprendizaje basado en proyectos, STEAM, formato KIKS, educación secundaria, internacionalización.

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1. Introduction and state of the question

Following a series of recommendations from Europe, current study plans emphasise the importance of acquiring and developing key competences (Consejo de la Unión Europea, 2018). Developing these competences has fomented the use of active methodologies as a way to guarantee a lifelong formation of citizens (López-Pastor, 2011; Paños-Castro, 2017). In secondary school classrooms, however, no meaningful changes have been observed in the intervention processes, or in the application of such methodologies (Valverde-Crespo et al., 2018). The factors that impede the development of competences include teacher resistance to change (Al-Salami et al., 2017; Monereo, 2010), and challenges inherent to implementing active methodologies (Vázquez-Cano, 2016). In addition, the excessive dependence on textbooks in countries like Spain does not promote the improvement of these competences (Toma & Greca, 2018).

One of the methodologies most often utilised to work on key competences is the STEM project-based learning. This methodology integrates the content of STEM subjects (Science, Technology, Engineering, and Mathematics) (Han et al., 2015) to form competent citizens capable of confronting the challenges of modern society (Acar et al., 2018; Maass et al., 2019), by narrowing the gap between the competences acquired under a traditional focus and those demanded by current professional contexts (Jang, 2016; Ward et al., 2014). STEM project-based learning centres primarily on fomenting the scientific-mathematical competence; this competence is often complemented with the digital one by integrating the search for information and the use of software into problem-solving activities (Domènech-Casal, 2018; Valverde-Crespo et al., 2018). There are various studies at the level of primary education that integrate the development of several competences using active methodologies (Martín & García, 2018). For secondary education, however, very few projects have been implemented to work on three or more competences conjointly. That is, no attempts have been made to undertake the integral development of all eight key competences in this educational stage.

Considering this background, in this article we present a three-year investigation in which 267 secondary school students from four countries developed the eight key competences globally, by elaborating projects under a STEAM project-based learning approach with KIKS format. The STEAM focus incorporates the A of Arts to integrate subjects from the areas of Humanities and Art with the scientific disciplines previously mentioned (Colucci-Gray et al., 2019). The acronym KIKS means Kids Inspire Kids for STEAM. The present international study is framed in the European Erasmus+ and H2020 programmes.

1.1. Key competences

Key competences are defined as a combination of knowledge, skills, and attitudes. Knowledge is made up of facts, concepts, and theories; skills include the ability to apply knowledge and obtain results, while attitudes refer to an individual's willingness to act in certain situations (Consejo de la Unión Europea, 2018). From a curricular perspective, learning by competences presupposes "a rupture with the traditional structure of academic disciplines and a commitment to an interdisciplinary approach in the teaching-learning process" (García-Raga & López-Martín, 2011: 537). After evaluating various recommendations, the Council of the European Union identified eight key competences: 1) literacy; 2) multilingual; 3) mathematical competence and competence in science, technology, and engineering; 4) digital; 5) personal, social, and learning-to-learn; 6) citizenship; 7) entrepreneurship; and (8) cultural awareness and expression.

Literacy competence is the ability to understand, express, and interpret information both oral and written, while multilingualism is related to fluency in one or more foreign languages. Mathematical competence and competence in science, technology, and engineering include the ability to formulate, apply, and interpret mathematics in daily life problems, as well as the ability to explain the natural world, propose questions, and extract conclusions. Digital competence involves various abilities such as utilising technologies safely and responsibly. Citizenship competence emphasises the capacity to participate fully in social and civic life, whereas personal, social and learning-to-learn competence comprises the capacity of managing time and learning both autonomously and collaboratively. Entrepreneurship competence relates to the ability to transform opportunities and ideas into acts, while cultural awareness and expression competence includes the capacity to understand and respect different cultural and artistic contexts.

Most European study plans have come to echo these competences with the goal of achieving lifelong learning and preparing citizens to confront the professional needs of modern society (Nordin & Sundberg, 2016). The development of competences has been propelled through various initiatives, including digital resources, citizen science, and reading clubs, as well as environmental and heritage contexts. Castillo (2008) and Valverde-Crespo et al. (2018) highlight, for example, the use of digital resources for developing mathematical competence and competence in science, technology and engineering. Digital resources have also been employed to foster ethical decision-making (Pérez-Escoda et al., 2014; Wesselink & Giaffredo, 2015), and to potentiate literacy (Marchal et al., 2018) and multilingual competences (Jalkanen & Vaarala, 2013) by videoconferencing (Tecedor & Campos-Dintrans, 2019) and listening to news in non-maternal languages (González-Villarón & Egido-Gálvez, 2017).

Education for sustainable development and environmental education have been presented as initiatives to motivate the learning of values and promote social and environmental justice (Agirreazkuenaga, 2020). Likewise, heritage and artistic education are used as resources that contribute to forming critical and reflexive citizens (Trabajo-Rite & Cuenca-López, 2020). Citizen science experiments, based on processes of co-creation, are employed to raise students' awareness of social needs and concerns (Senabre et al., 2018). Reading clubs stimulate several components of literacy competence, such as reading comprehension and literary judgement (Álvarez-Álvarez & Vejo-Saiz, 2017), whereas working in everyday contexts has been suggested as an effective instrument for enhancing students' critical faculties and fostering cooperation among peers (Santisteban, 2009). As deduced from the above, diverse initiatives and resources exist to work on key competences. Nevertheless, in terms of methodology, STEM project-based learning is the most often used approach to develop such competences (Domènech-Casal et al., 2019; Han et al., 2015).

1.2. STEM project-based learning

STEM project-based learning includes the typical features of the interdisciplinary approach (Slough & Milam, 2013), where teamwork and context play a fundamental role (Kennedy & Odell, 2014). The projects implemented are normally open-ended, unstructured in nature, leading themselves to processes of scientific search within a practical framework of design (Ayerbe-López & Perales-Palacios, 2020; Diego-Mantecón et al., 2019). The usual result of applying this methodology is a final product that puts into practice knowledge and skills from different subjects (Fuentes-Hurtado & González-Martínez, 2017). In recent years, the 'A' of Arts has been incorporated into STEM education, so the acronym was modified to STEAM. As a consequence, this approach includes developing projects that involve, in addition to scientific-technological disciplines, subjects in the Humanities, Social Sciences, and Art (Colucci-Gray et al., 2019).

Although STEAM practices are increasing, most research related to project-based learning and competence development is conducted through the earlier STEM approach. Normally, investigations analyse different dimensions of mathematical competence and competence in science, technology, and engineering. Afriana et al. (2016), for example, showed school students in Indonesia significantly improved their scientific competence, compared to a control group, after participating in a STEM programme.

Likewise, Acar et al. (2018) detected significantly higher grades in the area of sciences in a group of Turkish students. In a three-year longitudinal study of secondary students in the United States, Han et al. (2016) observed a marked enhancement in the development of mathematical skills in the fields of geometry and probability. In their work, Diego-Mantecón et al. (2019) obtained similar results with Spanish students after a two-year intervention, while in a shorter programme Sarican and Akgunduz (2018) detected a relation between STEM projects and scientific competence, though their analyses did not generate significant differences. Relations between other competences and STEM project-based learning have rarely been confirmed, although some authors suggest that this methodology promotes the personal, social, and learning-to-learn competence (Sarican & Akgunduz, 2018; Larmer et al., 2015), as well as literacy and multilingual competences (Viro & Joutsenlahti, 2018). To work on key competences globally, instead of individually, European initiatives like KIKS and STEMforYouth propose using a STEAM project-based learning approach with KIKS format (Blanco et al., 2019).

1.3. STEAM projects with KIKS format

STEAM project-based learning with KIKS format follows a well-defined elaboration process. All projects are undertaken in a non-maternal language, usually English, aiming to motivate others, who are not present, to learn STEAM subjects (Blanco et al., 2019). Students are active agents who carry out projects collaboratively under the supervision of teachers or educators in relevant areas. The latter are usually passive agents whose role is to provide support for students' decision-making. Projects are introduced when teachers pose the following challenge: how can we get other students interested in STEAM subjects? With this challenge student choose, under teachers' supervision, the project to be carried out. This may emerge from an idea expressed by the participants themselves or from a repository of activities designed by experts. Projects can vary in their complexity and duration according to participants' availability. Having settled on a project, participants proceed to outline, sequence, and distribute tasks. All team members collaborate in every stage of the project, from the initial proposal through the processes of investigation and experimentation, reaching agreement on solutions, solving problems, and designing the final product or conclusions. As part of the work, students must prepare a textual report and a video (Blanco et al., 2019). The report has to include a project description, its development, and the final result, with a strong focus on analytical aspects, while the video has to demonstrate the practical aspects, such as assembling materials, constructing artefacts, and describing their functioning or applicability. All students must also participate in presenting their work in videoconferences and face-to-face encounters at national and international events. During the exhibition period, teams can incorporate changes and improvements in their STEAM projects to adapt their presentations to different audiences.

A thorough literature review did not identify any research evaluating the influence of STEAM project-based learning on the enhancement of competences from a global perspective. The objective of our work, therefore, is to analyse the extent to which STEAM project-based learning with the KIKS format contributes to the integrated development of key competences. In line with this, we address the following question: to what extent is there a relationship between the implementation of STEAM projects with the KIKS format and the development of the eight key competences?

2. Materials and methods

To answer the research question, a battery of high school STEAM projects was designed alongside an implementation guide. The projects were devised by adapting Thibaut et al.'s (2018a; 2018b) framework which includes five dimensions: 1) integration of STEAM content; 2) problem-centred learning; 3) inquiry-based learning; 4) design-based learning; and 5) cooperative learning. The projects included content from at least two STEAM disciplines and were set in a problem-solving context that leads to a phase of investigation and design process, through a cooperative learning approach. These were implemented considering the features of the KIKS format (Blanco et al., 2019), so for each project, the students were asked to generate a text document in two languages and produce a video in their non-maternal language. Another requirement was to disseminate their results, both virtually and in person, through videoconferences, as well as national and international events. This action entailed an iterative process of enhancing their work as they were receiving feedback.

This investigation was conducted in the educational innovation context of the KIKS project, under the umbrella of the Erasmus+ programme, with continuity in Spain through the STEMforYouth project (H2020). Each partner called for the participation of high schools in their respective country (Finland, England, Spain, Hungary), in the regions of Jyväskylä, Cambridgeshire and Cantabria, and the city of Budapest (part of Buda). Schools were contacted via e-mail through the councils of education. We received responses from at least 30 educational centres in each country, some public others non-public. Teachers at those centres were invited to participate in the first phase of the programme, which comprised theoretical sessions on STEAM education, KIKS format, and key competences implications in study plans. After those sessions, teachers participated in various training workshops about the classroom implementation of STEAM projects with KIKS format. Most of these teachers completed training, but 77% refused to take part in the implementation phase. Their refusals were attributed to such obstacles as rigid class schedules, incompatibility with evaluation procedures, lack of support in their centres, and low self-confidence due to a lack of interdisciplinary knowledge.

As a result, the final sample of this study consisted of a total of 46 teachers and 267 students, at 29 secondary schools in the four countries, nobody had prior experience in implementing project-based learning in their classrooms. 53 student teams were formed, each with 4-6 members, depending on the project scope and complexity. The teams were supervised by at least one teacher from the STEAM areas and a KIKS trainer, researcher who acts as advisor during the project development; a total of 17 KIKS trainers joined the study. The study lasted three school years, with students beginning at the age of 13-14. Each team carried out at least three projects during school hours, within a minimum of two academic years. The projects were presented at educational congresses for teachers and researchers, school events for students, and science outreach activities for the general public. Online conferences were also organised by teams in different countries. Detailed information on the projects and events is found in the following repositories: https://bit.ly/KIKSWEB, and https://bit.ly/STEM4Yweb.

For data analysis, a qualitative approach was adopted because the research question sought to identify relations between STEAM project-based learning with the KIKS format and global development of key competences. In no case was the intention of the study to generalize results or validate cause-effect relationships among variables; rather, the goal was to deepen analyses in an exploratory manner by identifying possible relations between variables (Creswell, 2009), in this case between the STEAM-KIKS approach and the eight key competences. A quadrangular focus was employed to examine and contrast the data obtained from the semi-structured interviews held with teachers, students and KIKS trainers, and the observations made along the implementation process of the programme. Data were gathered before, during and after carrying out the projects, and the presentations at events. These observations and interviews allowed obtaining specific information on the factors that influenced the development of competences. Most of the information was compiled in video form for later analysis. Analyses were conducted to identify relations between the variables. For each competence, tables were employed to compile and cross-reference data from the interviews and observations. Once the data were cross-referenced, relations between the variables were established, extracting testimonies to support the outcomes. Table 1 synthesises, as an example, the guide utilised to analyse digital competence. The left column presents the question matrix applied to orient the interviews; the second and fourth columns show the characteristics of STEAM project-based learning approach and KIKS format, respectively. Finally, columns three and five provide gaps for researchers' comments on the knowledge, skill, or attitude promoted by the programme.

Table 1. Guide for interviews and observations (digital competence)

Questions posed to teachers, students and KIKS trainers	STEAM project-based learning	Knowledge, skill, or attitude identified	KIKS format	Knowledge, skill, or attitude Identified
What aspects of the programme contribute to the development of digital competence?	Integration of content		Preparing written documents in two languages	
	Problem-solving in context		Creating and editing videos in a non-maternal language	
	Inquiry-based learning		Videoconferencing in two languages	
	Design-based learning		Face-to-face presentations in two languages to different audiences	
	Cooperative learning		Improving projects through an iterative process	

3. Analysis and results

The data analysis from the observations and interviews with students, teachers, and trainers allowed examining in detail the relation between STEAM project-based learning with the KIKS format and the development of the eight key competences.

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3.1. Multilingual and literacy competence

The students from all four countries showed improvement in several components of linguistic competence in both their maternal language and a foreign language. They enhanced their oral expression as a result of the presentations prepared to disseminate their work. Pablo (Spanish teacher aged 38) expressed the following: "After various works, my students succeeded in making more organised presentations, explaining the steps followed in their projects clearly". Almost all the teachers and KIKS trainers coincided in observing that after the first year, the students improved their vocabulary and pronunciation in the non-maternal language. Balazs (Hungarian teacher aged 43) stated: "My students did not have fluent English, but after various videoconferences with foreign students they were able to make themselves better understood". Students also learned to adapt their discourse to different audiences when making presentations at educational congresses and outreach events. Mary (English trainer aged 35) affirmed that: "The students enhanced their oral and corporal expression, increasingly emphasising the important aspects of their projects. […] They looked at the audience and gesticulated to draw their attention". All these aspects facilitated interaction and dialogue with the attendees and the reception of feedback to amend their work. Ulla (Finnish student aged 15) indicated: "We really improved our presentations after visualising the videos with our teacher. It was a challenge for us not to repeat information".

3.2. Mathematical competence and competence in science, technology and engineering

The students enhanced this competence by solving projects in real contexts that integrated content typically studied separately in the classroom. They also started to become aware of the applicability of the content learnt at school, an advance that helped them understand the importance of learning such content. Tony (English student aged 14) said: "I never knew maths had such an important role. It was necessary to use maths in almost all the projects". Óscar (Spanish teacher aged 45) expressed the following: "My students learned that solving a real problem requires dividing it into parts, and applying content of various areas of knowledge". The projects entailed managing mathematical properties, and scientific and technological content. During their development, it became clear that several students had never assimilated some contents taught in regular lessons. Mirka (Finnish teacher aged 38) commented: "When we first proposed the projects, the students didn't realize they had to utilise content already studied". Zsolt (Hungarian student aged 17) indicated: "With the projects I was able to understand the laws of physics that I'd studied in previous courses and that I had never really understood". Nicolás (Spanish student aged 16) revealed: "I didn't understand what the drawings we made in technology lessons were good for, until I designed prototypes of the robot".

3.3. Digital competence

The students developed several aspects of digital competence, after being involved in the implementation of projects for several years. They utilised resources like computers, tablets, and mobile phones to look up information and prepare their presentations. The students also improved their abilities in taping and editing the videos produced for disseminating the results. Francisco (Spanish KIKS trainer aged 53) commented: "They used technological resources more and more; they even generated graphs to clearly display the information". Peter (English teacher aged 45) observed: "Some students voluntarily redid the video to improve its quality after looking into more sophisticated editing techniques". Digital media, like Twitter or Skype, served to facilitate communications among team members and to present their advances to third parties. In this regard, Celia (Spanish student aged 15) expressed: "Many of the doubts or suggestions we made to the teacher were sent by Twitter". Another benefit of their growing digital competence was that the students learned to operate free programmes for data-handling and dynamic geometry, such as Tracker and GeoGebra, respectively. Anne (English student aged 15), for example, declared: "I never thought GeoGebra could help me solve real problems. My maths teacher only used it to teach us functions".

3.4. Personal, social, learning-to-learn competence, and entrepreneurial competence

The personal, social and learning-to-learn, as well as the entrepreneurial competences were also strengthened during the programme immersion. Students contributed with creative ideas and made decisions on how to focus their work, and how deeply they should delve into the topic. The teachers acted as supervisors, but their participation usually remained secondary, especially when the teams had to develop strategies to confront specific tasks. Vilmos (Hungarian teacher aged 58) revealed: "In the first project, the students had difficulty in planning the work, and felt they were being forced to give ideas and arguments about the steps to follow". In this vein, Elisabeth (English teacher aged 41) commented: "I noticed improvement with respect to the work plan. [...] The students divided the work up among themselves, and I felt it was unnecessary to intervene". Other areas where improvement was observed were sharing presentation times, and the coordination of the team members. The students gained greater self-confidence as they advanced in the projects and came to see themselves as protagonists of their learning process, becoming able to assess their own progress. Matt (English KIKS trainer aged 59), for example, made this comment: "At the final events, the students divided the presentation time more equitably. At first, some refused to intervene and others went on too long".

3.5. Citizenship competence, and cultural awareness and expression competence

These two competences were promoted throughout the three-year programme. Several teams carried out projects in which the Arts and the cultural expressions were fundamental pillars. The project entitled 'Half-pointed Arches', for instance, included efforts to learn and incorporate, architectural, heritage, and artistic aspects, in addition to their work on the mathematical, technological, and engineering elements. The objective of the project 'Can Recycling' was not only to integrate content, but also to exploit artistic representations as a way to raise citizens' awareness of the importance of recycling. Other projects that stressed social sensitivity were 'Microorganisms in Everyday Objects', 'A Drop of Life', and 'Accessibility Ramps'. The students involved in the latter project consulted legislative documents to verify the suitability of ramps in their surroundings, using mathematical concepts and digital devices. This project also turned out to be an experience in citizen awareness for people with reduced mobility. Markku (Finnish student aged 15) commented: "After the videoconference, whenever I saw a ramp in my city, I asked myself if it was really practical for people in wheelchairs". The multicultural context in which the programme was developed was also enriching, as it offered opportunities to observe social, artistic, and cultural aspects of other societies. Lucía (Spanish student aged 14) added: "The Finns' presentation on 'Himmeli' [a typical Christmas object in that country] made me realise that these artistic figures are indeed sold in Spain". In both the virtual and face-to-face encounters, students manifested interest in the ideas and cultural aspects of others. Regarding the latter, for example, they emphasised the patrimonial and cultural knowledge acquired on the national and international trips.

4. Discussion and conclusions

The present study identified the relations between STEAM project-based learning with the KIKS format and the global development of the eight key competences. Our results concur with those of Han et al. (2015, 2016), Acar et al. (2018), Afriana et al. (2016), and Diego-Mantecón et al. (2019) in the sense that STEM practices contribute to developing mathematical competence and competence in science, technology and engineering. This study also reveals that the KIKS format makes it possible to work on, and strengthen, the other key competences. We were able to verify, for example, that carrying out STEAM projects in a foreign language promotes the multilingual competence. In contrast to traditional learning, the KIKS format not only demands students reading and writing in a language different from their mother tongue, but also fosters communication through exchanges of information in both virtual and face-to-face settings. These conclusions coincide with those obtained in studies of learning non-maternal languages by reaffirming that digital devices, videoconferences, and listening to native speakers all enhance multilingual competences (Jalkanen & Vaarala, 2013; Tecedor & Campos-Dintrans, 2019; González-Villarón & Egido-Gálvez, 2017). The KIKS format also supports literacy competence, when the students present their work at local events in their own language; a notion already defended by Viro and Joutsenlahti (2018).

The feature of the KIKS approach that urges students to generate written documents and videos has been shown to be effective in the development of the digital competence. This competence is further strengthened by the use of digital resources to look up information, design prototypes, and collect and analyse data. In this study, digital competence was not developed as an end in itself but, rather, as a natural medium through which projects could be generated due to its close linkage to the other key competences. Valverde-Crespo et al. (2018) underscored this conclusion when they argued that digital competence is an element of scientific competence. Years earlier, researchers had established other, similar, relations like those that exist between 'digital competence' and 'personal, social and learning-to-learn competence' (Wesselink & Giaffredo, 2015), as well as between the digital and the multilingual competences (Jalkanen & Vaarala, 2013).

Right from the project selection, the connection with KIKS format and project-based learning manifested the development of the personal, social and learning-to-learn competence and the entrepreneurial competence. The projects were chosen in accordance with students' interests, and in consensus with their teacher. Also, each student collaborated in every project stage, from the problem approach to the final presentation. The development of these two competences was enhanced by allowing the students to lead their own projects, plan the tasks, and find the most adequate sequence for performing them, as well as improving their work by analysing the feedback received during their presentations. It is noteworthy that the relation between carrying out STEM projects, 'entrepreneurial spirit' and 'critical thinking' had already been suggested, though not confirmed, by Sarican and Akgunduz (2018) and Larmer et al. (2015).

Although project-based learning is often implemented under a STEM framework (Domènech-Casal et al., 2019; Han et al., 2015, 2016) and certain reticence to use the STEAM focus still persists, the present study shows that the 'A' of Arts does indeed provide an extra dimension; one that fosters, among other aspects, the cultural awareness and expression competence. Our study reveals that apart from enhancing the scientific-mathematical and technological competence, it also develops aspects related to architectural, heritage, and artistic knowledge. The KIKS requirement of attending national and international events also aided in the development of citizenship competence, by allowing visits to different artistic and cultural settings and promoting interaction with people there. In this programme, various students participated, for example, in educational congresses in England, Spain, or Italy. Regarding citizenship competence, the topic of some projects raised both authors' and receivers' awareness of environmental and health practices.

The partial and global analyses of this study revealed that the improvement of the competences was produced as a consequence, not only of the approaches applied, but also of students' long-term participation in the programme (minimum two years). The iterative process of preparing and refining –essential characteristic of the KIKS format– required extra effort from the students to correct and enhance their projects during an ongoing period of evaluation and supervision. All our analyses indicate that the enhancement of competences was generated primarily in the second year. These conclusions concur with the results from Sarican and Akgunduz (2018) in suggesting that intensive STEM practices utilised during brief time periods rarely succeed in promoting competence development. More studies, however, are needed to bolster the consistency of these results.

It is important to emphasise that in addition to the benefits shown during the programme implementation, the observations identified barriers that suppose challenges for existing educational systems. Project-based learning with the KIKS format is not easily adapted to the fixed lesson scheduling of educational centres, nor are their methods of evaluation; these facts constituted obstacles to several teachers who initially showed interest in joining the programme. Workspaces like workshops, laboratories, and computer rooms are essential for implementing this programme, but are not always available in schools, or are inadequate. Since this instruction format requires fungible materials, technological components beyond those in common use, and attendance at educational events, a regulated institutional framework would be needed to provide supplementary human resources and financial support. We can also affirm that two of the main reasons why teachers refused to participate were a lack of training on the interdisciplinary focus, and inadequate support from other agents at their centres.

To further develop this line of research, quantitative investigations would be useful to analyse the relations identified in this study and to cross-reference the categorical variables not addressed herein, included gender, educational centres' characteristics, and socio-economic contexts. This future study would provide greater consistency to the results obtained to date and shed additional light on the nature and development of these eight key competences.

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