IIIEPE - A Laboratory for the Development of Stem Teaching Competencies Through Computational Thinking and Artificial Intelligence

Marcela Georgina Gómez-Zermeño, Instituto de Investigación, Innovación y Estudios de Posgrado para la Educación del Estado de Nuevo León, México
Lorena Alemán de la Garza, Instituto de Investigación, Innovación y Estudios de Posgrado para la Educación del Estado de Nuevo León, México

The Paris Conference on Education 2023
Official Conference Proceedings

Abstract
This article presents a teacher training strategy based on the design of an educational innovation laboratory that promotes the development of STEM teaching competencies through computational thinking and artificial intelligence in public schools in the State of Nuevo León, Mexico. Today, the development of computational thinking is a core teaching competency, which reveals the importance of integrating new strategies in teacher training programs mediated by artificial intelligence. According to the recommendations of the Beijing Consensus, AI can meet the challenges of developing innovative practices that contribute to the achievement of Sustainable Development Goal (SDG) 4, and its implementation has already begun to alter the traditional foundations of teaching and learning and raises profound questions related to professional teacher development. In this context, the Instituto de Investigación, Innovación y Posgrado para la Educación del Estado de Nuevo León in Mexico (IIIEPE) is designing the "Yancuic Miztli" (new lion in Nahuatl) laboratory, an educational innovation laboratory for teacher training that promotes active learning through generative artificial intelligence. IIIEPE aims to improve practices through teacher development, focusing on educational innovation. This laboratory is based on the collaborative work carried out by IIIEPE researchers with the research group of the multidisciplinary project IE-CARE, supported by the French National Research Agency (ANR), and focused on the design, implementation, and evaluation of pedagogical scenarios and digital educational resources.

Keywords: STEM Competencies, Teacher Training, Artificial Intelligence, Computational Thinking

Introduction

In all societies, capacity building in science, technology, art, engineering, and mathematics (STEAM) is crucial to promote sustainable development. To achieve the goals posed by the 2030 Agenda, STEAM Education provides an approach to cultivate critical thinking and develop transformative, innovative, and creative skills, in addition to forging the skills to turn students into empowered citizens who participate in addressing the problems that today affect localities, countries and regions across the globe (UNESCO, 2019).

The STEAM approach has become popular in various countries because it can combine arts with science, technology, mathematics, and engineering. STEAM teaching competencies generate innovation and motivation, besides associating logical thinking with creativity, making science more attractive to students (Meza & Duarte, 2020). In Mexico, the STEAM approach has been recognized as a valuable educational strategy for the implementation of the New Mexican School (NEM), a new educational model based on a set of educational policies and reforms that seek to transform the Mexican educational system and thus improve the inclusion, equity, and quality of education.

In this perspective, the STEAM approach aligns with the objectives of the NEM to promote an inclusive, participatory, comprehensive, and student-centered educational approach. By developing critical thinking, creativity, technological skills, and problem-solving, it seeks to prepare students to meet the challenges of the 21st century and develop the competencies necessary for their academic and personal success. Some of the ways this has been integrated include technology and teacher training.

This partial research report presents a strategy for the development of STEAM competencies in public school teachers in the State of Nuevo Leon in Mexico, based on the design of a laboratory that promotes computational thinking through Scratch programming and generative artificial intelligence to integrate technology into their educational practices in a meaningful way to enrich the learning of young students. It is based on collaborative research conducted by IIIEPE researchers with the working group of the multidisciplinary project IE-CARE, supported by the French National Research Agency (ANR), focusing on the design, implementation, and evaluation of pedagogical scenarios and educational resources for the development of computational thinking (ANR, 2023).

STEAM Teaching Competencies

In the New Mexican School, the integration of the STEAM approach seeks to foster a more inclusive, participatory, interdisciplinary educational approach oriented to the integral development of students. By promoting critical thinking, creativity, technological skills, and problem-solving, it seeks to prepare students to face the challenges of the 21st century. To achieve this, STEAM methodologies promote integrating and developing scientific-technical and artistic subjects in a single interdisciplinary framework (Yackman, 2008).

Through active learning strategies, complex problems are worked on from different disciplines giving creative and innovative solutions using technologies (Sevilla & Solano, 2020). To achieve this, teacher training strategies focus on improving educational stakeholders' skills and abilities to solve problems and awakening students' motivation towards interest in science and technology, adaptable to educational scenarios at all levels of primary education (Santillán et al., 2019).

In this regard, UNESCO recognizes that the prevalence of ICT is crucial in education, so it has developed the UNESCO Competency Framework for Teachers (UNESCO-ICTCFT), which offers a valuable tool to guide the initial training and search for teachers in education. With this toolkit, UNESCO seeks to provide a basis for up-to-date policy development and capacity building in the dynamic field of ICT. As shown in Table 1, developing teachers' pedagogical skills promotes the integration of technologies and complex problem-solving with complex tools (UNESCO, 2018).

Table 1. UNESCO's ICT Competency Framework for Teachers

	DIGITAL LITERACY	**KNOWLEDGE ENHANCEMENT**	**KNOWLEDGE CREATION**
PLACE OF ICT IN EDUCATION	Knowledge of policies	Description of directives	Policy innovation
CURRICULUM AND EVALUATION	Basic knowledge	Knowledge translation	Competencies in the knowledge society
PEDAGOGY	Technology integration	**Solving complex problems**	Self-management
ICT	Basic tools	**Complex tools**	Dissemination tools
ORGANIZATION AND ADMINISTRATION	Standard classes	Collaborative work	Learning organizations
TEACHER TRAINING	Digital literacy	Managing and guiding	The teacher as a learning model

Used by countries worldwide, the UNESCO-ICTCFT frames the role that technology can play in supporting six key areas of education through three phases of learning. It provides a reference for recent technological and pedagogical developments in ICT and education. It emphasizes the importance of teachers fostering students' skills for collaboration, problem-solving, and creativity in using digital technologies. In the digital era, these competencies become integral to their initial training (Montiel & Gómez-Zermeño, 2022).

Computational Thinking

One of the teachers' great challenges is meeting the digital transformation processes contemporary society faces. Teachers do not have the technical or pedagogical skills to develop computational thinking in their students (Alemán de la Garza et al., 2019). One of the main reasons is the lack of formal programs or curricula for this teacher qualification. Wing (2006) reports that Computational Thinking (CT) integrates the thinking processes in formulating problems and their solutions. It comprises four pillars: decomposition, pattern recognition, abstraction, and algorithms.

In 2011 the International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA) developed an operational definition of CT with the goal that teachers can introduce it to classrooms through a set of steps:

1. Formulate problems in a way that allows to use a computer and other tools to help solve them.
2. Organize and logically analyze data. Represent data through abstractions, such as models and simulations.
3. Automate solutions through algorithmic thinking (a series of ordered steps).
4. Identify, analyze, and implement possible solutions to achieve the most efficient and effective combination of steps and resources.
5. Generalize and transfer this process of solving a wide variety of problems.

Under this approach, strategies to develop STEAM teaching competencies through CT should not be limited to a specific subject within the teacher training curriculum since they should be viewed as a transversal axis in the curriculum that contributes to the construction of citizenship in equity that eliminates digital divides and allows problem-solving based on understanding and reasoning (Bucci, 2017).

Figure 1. ISTE Standards in Teacher Education

Scratch Programming

In 2003, the Scratch Project was initiated by a group of researchers at MIT Media Lab's Lifelong Kindergarten, under the direction and leadership of Dr. Michael Resnick, to provide an accessible programming environment for young students. This project received support from the National Science Foundation, Intel Foundation, Microsoft, MacArthur Foundation, LEGO Foundation, Code-to-Learn Foundation, Google, Dell, Fastly, Inversoft, and the MIT Media Lab research consortium.

As stated by Resnick et al. (2009), the original goal of Scratch was to develop a programming approach that would engage people, regardless of age, social or educational background, in developing algorithmic solutions without the complexities of syntax and semantics of traditional programming languages. This requires making Scratch a language for programming interactive stories, games, animations, and simulations easy for all its users, who can also share their creations with others.

In this way, the main goal of Scratch is not to prepare people for professional or technical programming careers but to nurture a new generation of creative and systematic thinkers using programming to express their ideas. Papert advocated that programming languages should have a "low floor" (easy to start programming) and a "high ceiling" (opportunities to create more complex projects over time). Escribano & Montoya (2012) corroborate that programming languages need "wide walls" (the ability to encompass different types of projects so that people with very diverse interests and styles are encouraged to program). To make these objectives possible, the creators of Scratch have introduced three basic principles or features in the design of this programming language:

1. The programming language must be playful.
2. The experience of using the programming language should be meaningful.
3. Using the programming language should be conducive to social interaction.

Nowadays, experience shows that Scratch is a good tool for the development of computational thinking in children in primary education since it offers an environment in which students are motivated and participate in the proposal of solutions without fear of error, enables the analysis of problems and the proposal, development, and application of logical and algorithmic solutions, which can be tested and improved (Montiel and Gomez-Zermeño. 2021).

Artificial Intelligence

Currently, competencies in computational thinking and its application and the development of Artificial Intelligence (AI) are changing teaching, learning, and ways of living and learning. Undoubtedly, AI has the potential to benefit and solve various social problems widely. AI is expected to significantly impact education and transform teaching practices with new teaching materials. It could revolutionize how students learn through personalized learning, increase access to knowledge, and facilitate more inclusive education (Chen et al., 2020).

In this context, UNESCO is currently developing an AI readiness self-assessment framework to assess the readiness and capacity to embrace and integrate AI technologies in all areas of education at the national level. In this way, it seeks to contribute to the readiness and capability of key stakeholders in national education systems to take advantage of the potential of AI to ensure inclusive, equitable, and quality education, as well as to provide new lifelong learning opportunities for all (Pedro et al., 2019).

Within this field of study, generative artificial intelligence (GAI) focuses on developing models and algorithms capable of generating original and creative content, such as images, music, text, or even videos, mimicking or surpassing human capacity in creativity and content production. To do so, generative artificial intelligence systems use machine learning and neural networks to learn from existing data sets and generate new creations based on that acquired knowledge. These models are trained on large amounts of data to capture specific patterns and features and can then generate unique content from that learned information (Baidoo-Anu et Ansah, 2023). Currently, generative artificial intelligence (GAI) has several potential applications in teacher education, and some of them are:

- Educational content generation
- Virtual tutoring
- Automated feedback
- Personalization of learning
- Creation of simulations and virtual learning environments

Method

This research sought to answer the question: *What elements are recommended to be integrated in the design of a laboratory to develop STEM teaching competencies through computational thinking and artificial intelligence?* Based on the research question, a method based on an exploratory study was adopted to make a first approach to this specific topic before addressing it in more in-depth research (Hernandez-Sampieri, 2018).

The design of the "AI-Xólotl" laboratory establishes its basis in the collaborative research conducted by IIIEPE researchers with the working group of the multidisciplinary project IE-CARE, supported by the French National Research Agency (ANR), and focused on the

design, implementation, and evaluation of pedagogical scenarios and educational resources that promote the development of STEAM teaching competencies in computational thinking.

Research Context

The research context is situated in the *New Mexican School* (NEM), an educational model proposed to transform the country's educational system. NEM seeks to promote inclusive, equitable, and quality education that fosters the integral development of students, encouraging their formation as responsible, critical citizens committed to their environment (SEP, 2022). With an emphasis on equity, NEM promotes differentiated structures and facilities that compensate for school inequalities. In the pedagogical principles and guidelines, the NEM associates students' ability to use ICT with the timely provision of technological infrastructure (hardware and software) and the development of STEM teaching skills in computational thinking.

Nuevo León has 546,714 children between the ages of 0 and 5 years. Of this population, the coverage of 3, 4, and 5-year-olds in the education system for the 2020-2021 cycle was 43.2%, 96.4%, and 103.3%, respectively. For the 2020-2021 school year, preschool education had coverage of 7.0% and preschool education of 70.0%. Girls and boys enrolled in the initial level were 8,963, 17.7% less than in the 2019-2020 cycle. On the other hand, preschool enrollment in the 2020-2021 cycle was 192,705 children, 7.9% less than in the 2019-2020 cycle. In the 2020-2021 school year, 3.4% of children between 3 and 5 years of age attending preschool presented some barrier to learning in the various formative fields (Gobierno del Estado de Nuevo León, 2022).

This study focused on exploring the Robotix program, implemented by the RobotiX Foundation with FIRST® LEGO® League, in alliance with the Nuevo León Secretary of Education (SENL), to promote the development of STEAM skills in preschool children. Through Robotix, the SENL emphasizes the importance of strengthening science, engineering, arts, and mathematics through play, creativity, and inventiveness. Fifty-three scholarships were awarded, including the delivery of educational materials to the directors of the beneficiary schools, of which 48 of the 53 scholarships are granted by the international educational program FIRST LEGO League and 5 scholarships are from the RobotiX in the Box program.

This program also proposed offering teacher training and various manuals to the beneficiary schools, designed to implement its methodological proposal. The program aims to have a direct impact on children in the regions of Sabinas Hidalgo, Salinas Victoria, Monterrey, San Nicolás, Santa Catarina, Cadereyta Jiménez, and Montemorelos, who will develop skills for problem-solving, collaborative and teamwork, improve their communication and interaction processes and, above all, to approach science and technology in a creative, playful and critical way.

Analysis of Results

Currently, the RobotiX program for STEAM skills development has been implemented in a total of 26 schools in the municipalities of Monterrey, San Nicolas de los Garza, Guadalupe, Apodaca, Juarez, Sabinas Hidalgo, Salinas Victoria, General Escobedo, and Cienega De Flores. During the exploratory study, 4 preschools were visited, which were selected by the

SENL. Interviews were conducted with principals and teachers, and observation guides were applied to generate information through three axes of analysis.

Pedagogical Methodology for the Development of Steam Skills in Preschool Students.

Results show that the RobotiX program seeks to provide students with a practical and playful experience, fostering creativity, critical thinking, and teamwork. Through activities, students develop essential skills such as logic, communication, and collaboration for problem-solving.

Its methodological proposal offers didactic materials and manuals to facilitate the development of students' STEAM skills. Some of the manuals provided are 1) Robot construction manual, 2) Programming manual,) Activities and challenges manual, and 4) Facilitator's or teacher's guides.

In the preschools visited, the young students use the "Six Bricks" manual, a learning tool that promotes the development of skills in the following formative fields:

- *Language:* describing in detail, giving clear instructions, explaining and justifying their reasoning, and telling stories so that children develop their language, communicate, and express their ideas.
- *Problem-solving:* Keeping their attention and remembering the task or challenge, setting goals and planning, coming up with creative ideas, and thinking about how to accomplish them.
- *Collaboration:* Working in pairs and teams involves taking turns, sharing material, learning from peers and their ideas, and giving everyone roles and responsibilities.

Participating schools had to finance the printing of the "Engineering Notebook" for each of their students, which the RobotiX Foundation designed in collaboration with FIRST® LEGO® League and the LEGO Foundation, for them to use the Lego kit that was given to them in activities on energy sources. The teachers received the "Team Meeting Guide" manual, which introduces the program's funding organizations and specifies the STEM skills the students will develop:

- *Science:* cause and effect, gravity, force, motion, and simple machines.
- *Technology:* tools and investigating how things work.
- *Engineering:* creating designs, building solutions, and problem-solving.
- *Mathematics:* abstract and quantitative reasoning, object attributes, and shape identification

Didactic Materials and Their Integration in the Teaching of the Formative Fields.

Upon analyzing the observation guides, evidence was obtained that each of the schools visited received the following materials:

- STEAM Park
- Discover SET
- Discover More
- Discover Engineering Notebook
- Discover Engineering Guide

Integrating these materials into the teaching plans depends on the teaching team of each school. It should be noted that none of the teaching materials specify the formative fields in which learning is promoted.

In the framework of preschool education in Mexico, the formative fields are thematic or learning areas that are considered fundamental for the comprehensive development of children:

- Knowledge and Scientific Thinking
- Ethics, Nature and Societies
- Human and Community
- Languages

These formative fields are interrelated and are addressed in an integrated manner in the preschool education curriculum in Mexico. Therefore, teachers design activities and learning experiences that allow children to explore and develop competencies in these fields throughout their preschool education.

Although the RobotiX program seeks to promote the development of STEAM skills through Educational Robotics and programming, only LEGO materials were found in the preschools, which, although they encourage learning in the formative fields, teachers must integrate this methodology in their teaching plans properly.

Of the four preschools visited, the preschool in the municipality of Juárez adequately integrates the materials in its teaching plans, thus linking the formative fields with the methodology. This preschool also stands out for offering a Scratch Programming Club, which also integrates parents. Although its success depends on the commitment of its director, teachers, and parents, it is evidence of the importance of integrating the entire school community in designing educational programs that seek to develop STEM skills.

Figure 2. RobotiX Program in Nuevo León

Teacher Training in STEAM Mediated by Generative Artificial Intelligence

The interviews with principals and teachers and the observation guides allowed us to generate information about the teacher training offered by the program. It is reported that only some teachers participated in a face-to-face training session. Subsequently, they have received some e-mail messages inviting them to Zoom sessions in which only the use of didactic materials, manuals, and especially the "Guide for Team Meetings" is addressed, which seeks that the girls and boys develop skills to:

- Use and apply FIRST Core Values, learning habits, and the engineering design process to create solutions.
- Explore the theme of the season and their ideas through collaboration, construction, and playful learning.
- Create and test their ideas and solutions.
- Share and communicate what they have learned with each other and with others.

The focus of the Robotix Foundation is to promote, from the curriculum, the implementation of STEAM educational methodologies for children and young people, as well as playful pedagogies for teachers in Mexico. However, the analysis of the manuals and interviews revealed the need to strengthen the training offered to teachers to integrate the didactic materials and manuals into their lesson plans.

No evidence was found on how the methodology promotes the formative fields and critical learning at the preschool level. In the interviews with educational stakeholders, it was reported that implementing a program that seeks to encourage the development of STEAM skills in preschool children also requires offering a training program to develop STEAM teaching competencies in computational thinking.

Given the lack of teacher training programs or formal curricula that develop this teaching qualification, the use of the tools currently offered by generative artificial intelligence was explored with the educational stakeholders. ChatGPT was used as a teacher training strategy in exercises focused on strengthening STEM teaching competencies and developing computational thinking. Both the acceptance of teachers and the potential offered by generative artificial intelligence (GAI) in teacher training were observed.

Conclusions

This explanatory study corroborates the need to apply the STEAM approach from preschool education to develop critical skills such as computational thinking for problem-solving, creativity, collaboration, and technological skills, preparing students to succeed in today's and tomorrow's world. Global organizations such as UNESCO and UNICEF report that the most important stages of children's lives occur before they enter elementary school for the first time. By age five, a child's brain has reached 90 percent of its development, and the foundations for success in school and the rest of life are already in place.

Through the analysis of the results, relevant information was obtained for designing the "Yancuic Miztli" laboratory, a strategy for developing STEAM teaching skills in computational thinking through Scratch programming and artificial intelligence. Applying the STEAM approach through Scratch programming and artificial intelligence promotes the development of knowledge in which the content of each of these branches is worked in an interdisciplinary way to ensure meaningful learning. To achieve this, it is necessary to design

new training strategies that promote the development of STEAM teaching skills in computational thinking.

Although GAI has the potential to improve teacher training, the role of the teacher as facilitator and guide in the educational process remains fundamental. GAI should be a complementary tool to support and enrich teaching rather than replace it altogether. Today, the GAI has exciting potential in teacher training due to its ability to provide real-time answers and assistance on various educational topics. It can provide ideas and suggestions for teacher planning, pedagogical strategies, activities, or new teaching approaches.

Acknowledgment

This initial report results from the research work carried out in the General Directorate of Research and the General Directorate of Innovation Technology and Postgraduate Studies for Education of the State of Nuevo León, Mexico (IIIEPE). We appreciate all the support given to us by Dr. Lorena Gurrola, Rector of IIIEPE, and we express recognition to all its high-level academic community made up of education professionals: trainers, researchers, and technologists committed to improving the Educational quality. We also acknowledge the support given by Dr. Jesús Homero Trujillo Flores and Dra. Norma Leticia Castilleja Gámez from the Directorate of Preschool of the State of Nuevo Leon our manifest our recognition for his committed educational work.

References

Agence nationale de la recherche (ANR). (2023). *Computer sciences at school: conceptualizations, accompanying, resources – IECARE*. Paris. Available: https://anr.fr//Project-ANR-18-CE38-0008

Alemán de la Garza, L., Bruillard, E., Gómez-Zermeño, M., et al. (2019). *Rethinking pedagogy: Exploring the potential of digital technology in achieving quality education.* UNESCO-UNESCO Mahatma Gandhi Institute of Education for Peace and Sustainable Development (MGIEP). Available: https://unesdoc.unesco.org/ark:/48223/pf0000372786

Baidoo-Anu, D., & Owusu Ansah, L. (2023). *Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning.* Available at SSRN 4337484.

Bravo, F.A., & Forero, A. (2012). La robótica como un recurso para facilitar el aprendizaje y desarrollo de competencias generales. *Teoría de la Educación, 13*(2), 120-136. https://bit.ly/2EtOVnJ

Bucci, T. T., Cherup, S., Cunningham, A., & Petrosino, A. J. (2003). ISTE standards in teacher education: A collection of practical examples. *The Teacher Educator*, *39*(2), 95-114.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *Ieee Access*, *8*, 75264-75278.

Escribano, C. L., & Sánchez-Montoya, R. (2012). Scratch y necesidades educativas especiales: Programación para todos. *Revista de educación a distancia (RED)*, (34).

Gobierno del Estado de Nuevo León. (2022). Plan Estatal de Desarrollo (PED) 2022-2027. Gobierno de Nuevo León. Available: https://www.nl.gob.mx/plan-estatal-de-desarrollo-2022-2027

Meza, H. & Duarte, E. (2020). La metodología STEAM en el desarrollo de competencias y la resolución de problemas. [Conference]. ll Congreso Internacional de Educación: UNA nueva mirada en la mediación pedagógica. Costa Rica. Available: https://bit.ly/3foQulz

Montiel, H., & Gomez-Zermeño, M. G. (2021). Educational challenges for computational thinking in k–12 education: A systematic literature review of "scratch" as an innovative programming tool. *Computers*, *10*(6), 69.

Montiel, H., & Gomez-Zermeño, M. G. (2022, January). Rock the Boat! Shaken by the COVID-19 Crisis: A Review on Teachers' Competencies in ICT. In *Frontiers in Education* (Vol. 6, p. 558). Frontiers.

Moro, M., Agatolio, F., & Menegatti, E. (2018). The RoboESL Project: Development, evaluation, and outcomes regarding the proposed robotic enhanced curricula. *International Journal of Smart Education and Urban Society, 9*(1), 48-60. https://doi.org/10.4018/ijseus.2018010105

Muñoz-Repiso, A. G. V., & González, Y. A. C. (2019). Robótica para desarrollar el pensamiento computacional en Educación Infantil. *Comunicar: Revista científica iberoamericana de comunicación y educación*, (59), 63-72.

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). *Artificial intelligence in education: Challenges and opportunities for sustainable development.*

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Siver, J., Silverman, B., y Kafay,Y. (2009). Scratch: Programming for all. *Communications of the ACM, 52*(1), 60-67.

Santillán, J.P., Cadena, V.del C., & Cadena, M. (2019). Educación Steam: Entrada a la sociedad del conocimiento. *Ciencia Digital, 3*(3.4.), 212-227. https://doi.org/10.33262/cienciadigital.v3i3.4.847.

Secretaría de Educación Pública. (2022). La Nueva Escuela Mexicana. Mexico. Available: https://dfa.edomex.gob.mx/sites/dfa.edomex.gob.mx/files/files/NEM%20principios%20y%20orientacio%C3%ADn%20pedago%C3%ADgica.pdf

Sevilla, S., Solano, N., (2020). Supervisión 21. *Revista de Educación e Inspección, 55,* 1-24. https://bit.ly/3j3x3B1

UNESCO (2018). *Référentiel UNESCO de compétences TIC pour les enseignants*. Paris: NESCO. https://unesdoc.unesco.org/ark:/48223/pf0000368966

UNESCO. (2019). *Necesaria la educación STEAM+H para cultivar un pensamiento y habilidades transformadoras, innovadoras y creativas para avanzar hacia un desarrollo sostenible.* Paris. Available: https://www.unesco.org/es/articles/necesaria-la-educacion-steamh-para-cultivar-un-pensamiento-y-habilidades-transformadoras-innovadoras

UNESCO. (2019). *Artificial Intelligence.* Available: https://www.unesco.org/es/artificial-intelligence

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33-35.

Yakman, G. (2008). STEAM education: An overview of creating a model of integrative education. [Conference]. En *Pupils' Attitudes Towards Technology* (PATT-15). Salt Lake City, USA.