Design of a proposal for the recognition of emotional expression using Machine Learning in Education

Alejandro De la Hoz Serrano, Lina Viviana Melo Niño, Miguel Ángel Martín Tardío, João Piedade, Florentina Cañada Cañada, Javier Cubero Juánez

Abstract

The advancement of technology demands training in Artificial Intelligence, Machine Learning and Computational Thinking skills. Advances in Neurocognition and Neuroeducation underline the importance of emotions during the learning of scientific and mathematical contents. The study focuses on an educational intervention proposal using Machine Learning and Artificial Intelligence to work on Computational Thinking skills and emotional recognition and expression in Primary Education. First, an unplugged activity is designed. Subsequently, a Scratch® programming on the emotions felt by students during science and math activities is carried out. The last activity allows to update the emotional recognition since the facial expression changes continuously, by using Machine Learning for Kids. Machine Learning can be carried out in initial stages through adapted activities, to develop Computational Thinking skills, as well as to work on emotions, which is why this type of proposal is promoted during the learning of scientific and mathematical content.

Keywords:

Artificial Intelligence; Machine Learning; Emotion recognition; Computational Thinking; Elementary school.

Desenvolvimento de uma proposta para o reconhecimento da expressão emocional utilizando Machine Learning na Educação

Resumo: O avanço da tecnologia exige a formação em Inteligência Artificial, *Machine Learning* e competências de Pensamento Computacional. Os avanços em Neurocognição e Neuroeducação destacam a importância das emoções durante a aprendizagem de conteúdos científicos e matemáticos. O estudo centra-se numa proposta de intervenção educativa que utiliza a *Machine Learning* e a Inteligência Artificial para trabalhar as competências de Pensamento Computacional e de reconhecimento e expressão emocional no Ensino Básico. Primeiramente, é concebida uma atividade desconectada. Posteriormente, é realizada uma programação em Scratch® sobre as emoções sentidas pelos alunos durante as atividades de ciências e matemática. A última atividade permite atualizar o reconhecimento emocional, uma vez que a expressão facial muda continuamente, utilizando *Machine Learning for Kids*. A Aprendizagem Automática pode ser realizada em fases iniciais através de atividades adaptadas, para desenvolver competências de Pensamento Computacional, bem como para trabalhar as emoções, razão pela qual este tipo de proposta é promovido durante a aprendizagem de conteúdos científicos e matemáticos.

Palavras-chave: Inteligência Artificial; Machine Learning; Reconhecimento de emoções; Pensamento Computacional; Ensino Fundamental.

Conception d'une proposition pour la reconnaissance de l'expression émotionnelle en utilisant l'apprentissage automatique dans l'éducation

Résumé: Les progrès de la technologie exigent une formation en intelligence artificielle, Machine Learning et en compétences de pensée computationnelle. Les progrès de la neurocognition et de la neuroéducation soulignent l'importance des émotions lors de l'apprentissage de contenus scientifiques et mathématiques. L'étude se concentre sur une proposition d'intervention éducative utilisant l'apprentissage automatique et l'intelligence artificielle pour travailler sur les compétences de pensée informatique et sur la reconnaissance et l'expression des émotions dans l'enseignement primaire. Tout d'abord, une activité non connectée est conçue. Ensuite, une programmation Scratch® sur les émotions ressenties par les élèves lors d'activités scientifiques et mathématiques est réalisée. La dernière activité permet de mettre à jour la reconnaissance des émotions puisque l'expression faciale change continuellement, en utilisant l'apprentissage automatique pour les enfants (*Machine Learning for Kids*). Machine Learning peut être réalisé dans les phases initiales par le biais d'activités adaptées, afin de développer les compétences en matière de pensée informatique et de travailler sur les émotions. C'est pourquoi ce type de proposition est encouragé dans le cadre de l'apprentissage des contenus scientifiques et mathématiques.

Mots-clés : Intelligence artificielle; Machine Learning; Reconnaissance des émotions; Pensée informatique; École primaire.

Diseño de una propuesta para el reconocimiento de la expresión emocional utilizando Machine Learning en la educación

Resumen: El avance de la tecnología exige la formación en habilidades de Inteligencia Artificial, Machine Learning y Pensamiento Computacional. Los avances en Neurocognición y Neuroeducación subrayan la importancia de las emociones durante el aprendizaje de contenidos científicos y matemáticos. El estudio se centra en una propuesta de intervención educativa utilizando el Machine Learning y la Inteligencia Artificial para trabajar las habilidades de Pensamiento Computacional y el reconocimiento y expresión emocional en Educación Primaria. En primer lugar, se diseña una actividad desconectada. Posteriormente, se realiza una programación en Scratch® sobre las emociones que sienten los alumnos durante las actividades de ciencias y matemáticas. La última actividad permite actualizar el reconocimiento emocional ya que la expresión facial cambia continuamente, mediante el uso de *Machine Learning for Kids*. El Machine Learning se puede llevar a cabo en etapas iniciales a través de actividades adaptadas, para desarrollar habilidades de Pensamiento Computacional, así como para trabajar las emociones, por lo que se promueve este tipo de propuestas durante el aprendizaje de contenidos científicos y matemáticos.

Palabras clave: Inteligencia Artificial; Machine Learning; Reconocimiento de emociones; Pensamiento Computacional; Educación Primaria.

Introduction

One of the priorities of the European Commission is a Europe ready for the digital age, driving a European Union (EU) digital strategy to empower people with a new generation of technologies (Bocconi et al., 2022). The digital transformation has affected all spheres of society, with an increasing impact on education (Bocconi et al., 2022). Within this paradigm, it is crucial to understand how to integrate and assess the impact of technologies in the learning process, particularly in subjects that are more difficult to comprehend.

In this context, the European Commission's Digital Education Action Plan 2021-2027 is an EU initiative focused on readjusting education and training to support the sustainable and effective adaptation of education and training systems to the digital age (Bocconi et al., 2022). Computer literacy is listed in the second priority area as one of the requirements for strengthening the skills and competencies of young people, which are essential for developing a critical and practical understanding of the digital world in which they operate.

The introduction of Artificial Intelligence (AI) highlights issues such as didactics, organizational structures, access, ethics, equity, and sustainability, given that to automate something, it must first be thoroughly understood. Furthermore, to fully exploit AI's potential in supporting education, it is necessary to identify and leverage all its benefits, as well as recognize and mitigate its risks (Chen et al., 2020). According to UNESCO (2021), AI has the capacity to address some of the most significant challenges facing education today, develop innovative teaching and learning practices, and accelerate progress in achieving Sustainable Development Goal (SDG) 4.

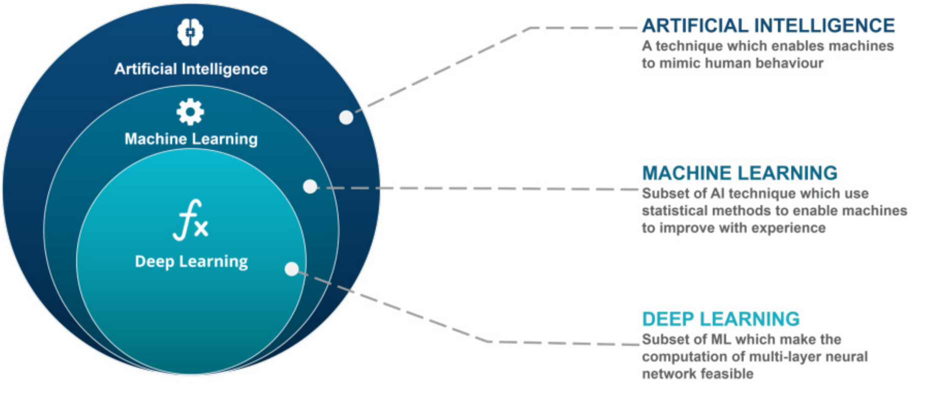
Over the last two decades, studies have highlighted the importance of emotions in learning processes, particularly in subjects that are very challenging to understand, such as science or mathematics (Blanco et al., 2010; Mellado et al., 2014). Therefore, research is essential to explore the integration of new digital tools based on AI and Machine Learning (ML) in the teaching and learning of scientific and mathematical content, with the goal of assisting in the identification of emotions exhibited by students during the learning process.

Literature review

Some of the benefits that AI can bring to educational innovation are: *Personalization of learning*: AI makes it possible to personalize the educational process according to the individual needs of each student or the various types of intelligence, thus enabling the creation of more tailored classes; *Early detection of difficulties*: AI has the ability to identify patterns in student performance, as well as problems or challenges in the learning process; *Constant feedback*: AI is able to provide students with continuous, real-time feedback, which helps them rectify errors and improve their learning; *Greater accessibility*: AI facilitates students with disabilities or particular requirements to access education more efficiently, providing them with personalized tools and resources that enable better understanding, tailored to their needs; *Improved efficiency*: AI can carry out the automation of numerous administrative responsibilities within the educational environment, which would help teachers invest more time in teaching and assisting students; *Continuous learning*: AI monitors the evolution of students over time and in an uninterrupted manner, offering an accurate view of their progress and development (Bocconi et al., 2022; Chen et al., 2020; García-Peñalvo et al., 2024).

As shown in Figure 1, within AI, Machine Learning (ML) and Deep Learning (DL) appear as branches of AI, which are widely investigated in the scientific literature (Forero-Corba and Bennasar, 2024; Guaña-Moya et al., 2022; Tedre et al., 2021). The scientific community is paying increasing attention to educational tools enriched with intelligent technology, highlighting their application in topics such as teacher and student perception, academic performance or Computational Thinking (Forero-Corba and Bennasar, 2024). ML refers to automatic learning through data analysis and pattern identification. Based on the knowledge acquired, ML models then make predictions. DL is a subfield within ML that "employs neural networks in different schemes to achieve learning from successive layers of increasingly relevant data representations". (Guaña-Moya et al., 2022, p.119)

Figure 1
Artificial Intelligence, Machine Learning and Deep Learning. Reproduced from Aggarwal et al. (2022).



In the field of compulsory education, several valuable machine learning initiatives have emerged, such as *Machine Learning for Middle Schoolers*, based on the Wolfram

Programming Lab, Google's Teachable Machine 2© and *Machine Learning for Kids,* based on IBM Watson©, among others. Machine learning education in primary and secondary schools has been addressed from different approaches. For example, Facial Recognition and Robotics have been used to teach AI concepts, and experiments have been carried out with gesture recognition to investigate how students learn to understand the basic work processes of machine learning (Guaña-Moya et al., 2022; Tedre et al., 2021).

As a result, numerous ML initiatives in the K-12 educational domain are focused on providing flexible and accessible tools that apply to a variety of areas. A prominent example is the ability to describe emotions through music, demonstrating the versatility and reach of these technologies in educational contexts, image recognition and speech recognition and synthesis (Vartiainen et al., 2021). Facial recognition and robotics have also been used to teach AI concepts (Ho et al., 2019) and experiments with gesture recognition have been conducted to study how children learn to understand basic ML workflows (Zimmermann-Niefield et al., 2019).

Different frameworks and references for the integration of AI into early-stage education curriculum plans have been introduced by UNESCO (2021), the EU through the recently updated *Digcomp* framework, and AI4K12 in the USA with its five key AI ideas to foster AI literacy (Gallardo et al., 2023). In turn, introducing AI content in school is necessary to awaken vocation among young people and address the growing number of STEM and AI positions expected in the near future (García-Peñaldo et al., 2024). Under this context, Computational Thinking (CT) constitutes an appropriate framework to introduce AI content in schools through both coding and disconnected hands-on activities. CT is a basic problem-solving skill that relies on computer science concepts and techniques such as decomposition, pattern recognition, abstraction, and algorithms (Bocconi et al., 2022)

The integration of AI and CT has been analyzed in recent studies due to the emerging interest of educational researchers (Hsu et al., 2023; Weng et al., 2024). Researchers have noted that integrating AI and CT into education can help students develop critical, technological, and problem-solving skills essential in the 21st century (Hsu et al., 2023; Weng et al., 2024). Under this paradigm, when students perform AI and ML activities, various CT skills are worked on, such as *sequences, loops, events, parallelism, conditionals,* and *operators.* As mentioned by Weng et al.: "a researchable question would be how to effectively design AI-relevant activities to foster student development in CT and how to appropriately design CT-rich activities to enhance student learning in AI.". (Weng et al., 2024, p.3)

At the same time, among the different technological resources with great boom, Educational Robotics (ER) and programming are presented as outstanding tools in the international panorama. Previous studies (Anđić et al., 2024) have shown that it involves an improvement of cognitive and metacognitive skills such as critical thinking, self-efficacy, problem-solving and Computational Thinking; it also allows improving social skills as a consequence of active and collaborative learning; it allows improving knowledge and competences associated with scientific disciplines (Jaipal-Jamani and Angeli, 2017). For all these reasons, ER and programming have been introduced in recent years into the educational laws of multiple countries worldwide. This has led to an increased demand for professional training, fostering research and teaching in higher education and universities on the alternatives offered by these digital resources (Schina et al., 2021).

Teachers exploring AI, programming, and ER find computational thinking to be a framework for introducing such content in schools. It is endorsed by many researchers as an innovative learning tool, capable of transforming education and supporting students across various learning contexts (Bocconi et al., 2022; Weng et al., 2024). Salas-Pilco (2020) states that AI and robotics have become catalysts for early learning fluency in science and technology. Under this paradigm, the challenge is to find a way to introduce AI to students in an accessible and simple way, boosting and fostering interest in learning and training in these tools.

Conversely, the intersection between the neuroscientific disciplines of neurocognition and neuroeducation provides a framework for understanding and enhancing scientific and technological literacy (Mora, 2021). Neurocognition provides us with a deep understanding of how the human brain processes and assimilates information, while Neuroeducation allows us to design teaching strategies that take advantage of these cognitive processes. By integrating these approaches, more effective teaching methods can be developed in order to take advantage of the brain's learning mechanisms, promoting a deeper and more lasting understanding of scientific and technological concepts in students.

This holistic approach acknowledges the importance of addressing both cognitive and socioemotional aspects of learning, which contributes to the comprehensive development of individuals capable of successfully facing the challenges of an increasingly knowledge-based society (Barrios & Gutiérrez, 2020). Thanks to advances in neuroscience and technologies to study brain functions, it is now possible to understand the neurostructural and neurofunctional basis of the relationship between cognition and emotion. This network is formed by an integrated system of the amygdala cortex, which connects with systems including the ventral striatum, septum, hippocampus, hypothalamus, brainstem, thalamus, insula, and cingulate cortex. These components, regulated by various neurotransmitters, organize the expression of emotional experience from different systems, controlling somatic and visceral motor effectors, voluntary movements, and emotional expressions, among others (Barrios & Gutiérrez, 2020).

In this context, since the end of the last century and especially in the last decade, there has been an increasing amount of research studying the influence of the affective domain on the teaching and learning of science and mathematics, largely due to the rise in academic decline in these areas (Blanco et al., 2010; Mellado et al., 2014).

In particular, the study of the emotions presented by students during the learning of certain subjects is fundamental, since the affective and cognitive domains present an indissociable duality (Mora, 2021). Bisquerra (2003) argues that emotions are reactions of different intensity depending on the information received from the environment and according to the (subjective) evaluation of each person. The emergence of negative attitudes and emotions is considerably affecting not only the scholastic progress of students, but also the choice of higher studies, producing a significant decline in scientific vocations (Del Rosal, 2023; Martínez-Borreguero et al., 2018). Currently, there is an increase in students' disinterest in learning curiosity about scientific and mathematical contents, which intensifies a distancing from these fields as they advance in their educational stages (Vázquez & Manassero, 2011).

Specifically, during the primary education stage, there is an important emotional development in students. Thus, they progress from recognizing basic emotions to understanding and experiencing more complex emotions; they can even understand the existence of contradictory emotions, know and adopt rules for the expression of emotions and learn to control them (Del Rosal, 2023; Gallardo-Vázquez, 2006). Martínez-Borreguero et al. (2018) show more extraordinary positive emotions in primary school students than in higher educational stages, who tend to emphasize negative emotions. The positive emotions experienced in the initial stages in scientific fields should serve to consolidate them for the following higher stages. In view of this, it is necessary to analyse students' emotions under innovative teaching approaches. This coincides with the study of Del Rosal and Bermejo (2018), reporting the predominance of emotions such as *joy*, *fun* and *confidence* in science content, especially under active interventions. Similarly, Molera (2012) analyzes and describes the importance of affective factors, such as emotions, beliefs and attitudes in the teaching-learning process of mathematics in students in the 5th and 6th grades of primary education. Moreover, in recent years, positive emotions arising through STEM methodologies have been highlighted (Martínez-Borreguero et al., 2018; Mateos-Nunez et al., 2020), being one of the most appropriate methodologies for the integration of ER (Bocconi et al., 2022).

However, different studies (Blanco et al., 2010; Hidalgo, Maroto y Palacios, 2004) detail certain negative emotions towards science and mathematics, which may be related to a beginning of attitudinal, cognitive and competency decline. Recent studies demonstrate the potential of Educational Robotics in improving students' attitudes, emotions and predispositions towards scientific, mathematical and technological disciplines (Atmatzidou & Demetriadis, 2016; Del Olmo-Muñoz et al., 2020).

There is a need to understand the emotions of students at this educational stage under these new educational supports, to improve their scientific and mathematical competence (Martínez-Borreguero et al., 2018). Research into recognising and expressing feelings in science and maths learning should be developed using innovative resources and methods. Therefore, the aim of this study focuses on the design of activities based on the use of AI to analyse primary education students' emotions while learning scientific and mathematical contents.

Pedagogical proposal

Design

The proposed activities are designed to be carried out in the 5th and 6th grades of primary education and can be adapted to previous grades of the same educational stage and even to a later stage, depending on the program's complexity.

The intervention is carried out using unplugged boards, Scratch® and *Machine Learning for Kids* software applications. Unplugged activities are described as activities for learning computer science skills without a computer, implemented with tools such as board games, toys, cards, puzzles, and papers (Chen et al., 2023). Scratch® is a free visual programming software that allows users to create interactive multimedia projects based on Logo's constructivist learning ideas (Escribano & Sánchez-Montoya, 2012). *Machine Learning for Kids* is an application that provides access to a machine learning system and allows its algorithm to be exported to a programming language such as Scratch® or Python (INTEF, 2024).

Proposal for educational intervention

The design of the didactic proposal focuses on using the fundamentals of programming and AI to work on the emotions of primary school students in the context of learning science and mathematics content. The educational intervention focuses on three complementary activities. First, an unplugged activity is carried out to develop initial and basic computational thinking skills through the use of boards and tangible cards. The board is composed of different concepts and images that represent several emotions to allow students to comprehend the diverse emotions they have experienced during the performance of science and mathematics activities.

The second activity then focuses on the use of Scratch® software for the creation of questionnaires. These questionnaires are intended to be used so that students have to link the emotions that arise (during the learning of science and mathematics content) with images that reflect each emotion so that a visual expression of the emotion can appear on the screen according to what each student has felt. The subsequent activity involves learning and using the *Machine Learning for Kids* tool. In this case, the objective focuses on students learning to differentiate emotions through facial recognition of the students themselves. To do this, the different emotions worked on in the previous activity are broken down, and the software is trained so that there is a clear differentiation through the facial expression of each emotion. This training consists of using a bank of images (it could also be done with other information input sources) for each variable used, in this case, for each emotion. In this way, the corresponding emotion is specified for each image so that the AI recognizes the characteristic patterns of similarity and differentiation so that when new images are presented to it, it can discriminate the corresponding emotion.

Subsequently, programming is carried out to use the training previously used. In this case, programming is carried out to display on the screen the emotion expressed thanks to the recognition of AI. Table 1 shows the computational thinking skills developed in each complementary activity.

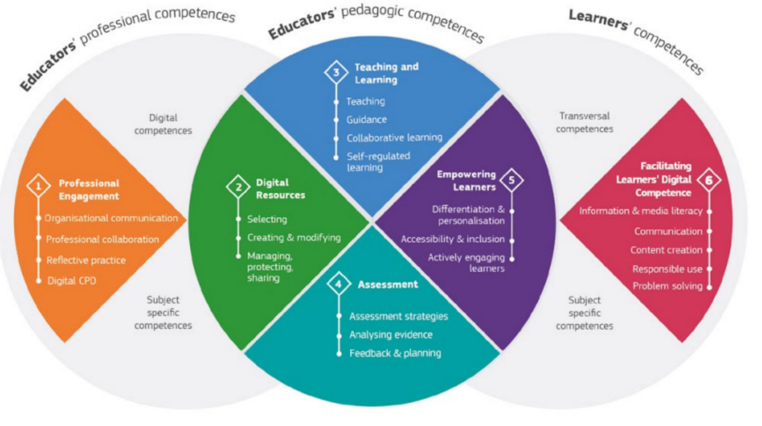
Table 1
The CT skills model applied in the current study

CT SKILL	DESCRIPTION, LEARNING COMPONENTS AND APPROACHES	ACTIVITY
Decomposition	Process of breaking down problems into smaller parts that may be more easily solved	Board and tangible programming block Scratch® questionnaires Machine Learning for Kids
Pattern recognition	Identify patterns/rules underlying the data/ information structure	Machine Learning for Kids
Abstraction	Process of creating something simple from something complicated, by leaving out the irrelevant details	Machine Learning for Kids
Algorithms	Practice of writing step-by-step specific and explicit instructions for carrying out a process.	Board and tangible programming block Scratch® questionnaires Machine Learning for Kids
Debugging	Detect and identify errors, and then fix the errors, when a solution does not work as it should.	Board and tangible programming block Scratch® questionnaires Machine Learning for Kids
Interaction	Repeat design processes to refine solutions, until the ideal result is achieved.	Board and tangible programming block Scratch® questionnaires Machine Learning for Kids

Ethics and privacy

It is important to consider privacy and ethics when using facial recognition in educational settings, especially with children. In order to determine an appropriate use of technology in terms of privacy and ethics, the most relevant points are described within the Framework of Reference for Digital Competence in Education (MRCDD) (Redecker, 2017) as a relevant guide at the European level on the use of technology in education (Figure 2).

Figure 2
DigCompEdu Areas and Scope© European Union. Reproduced from Redecker (2017).

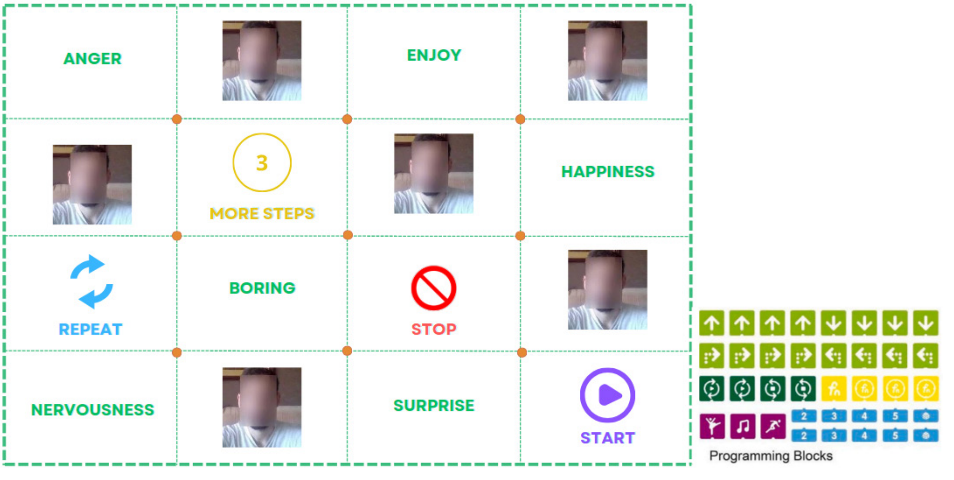


As part of area 1: *Professional commitment*, in subarea 1.3: *Educational practice*, it is reflected in level B2.3. Likewise, in subarea 1.5: *Protection of personal data*, privacy, *security and digital well-being*, at level A2.1., C1.2. and C2.1. Within area 6: *Development of students' digital competence*, in subarea 6.4: *Responsible use and digital well-being*, it is located at level A1.3., A2.2. and C2.1.

Scenario of Implementation

As an initial activity, a board is seen to work on CT skills in an unplugged way (Figure 3). This board allows students to start by working with a series of emotions, helping them relate each emotion to its corresponding facial expression. This enables students to recognize the importance of facial expressions in conveying emotions. To do this, different tangible programming blocks are used (Zhang et al., 2024)

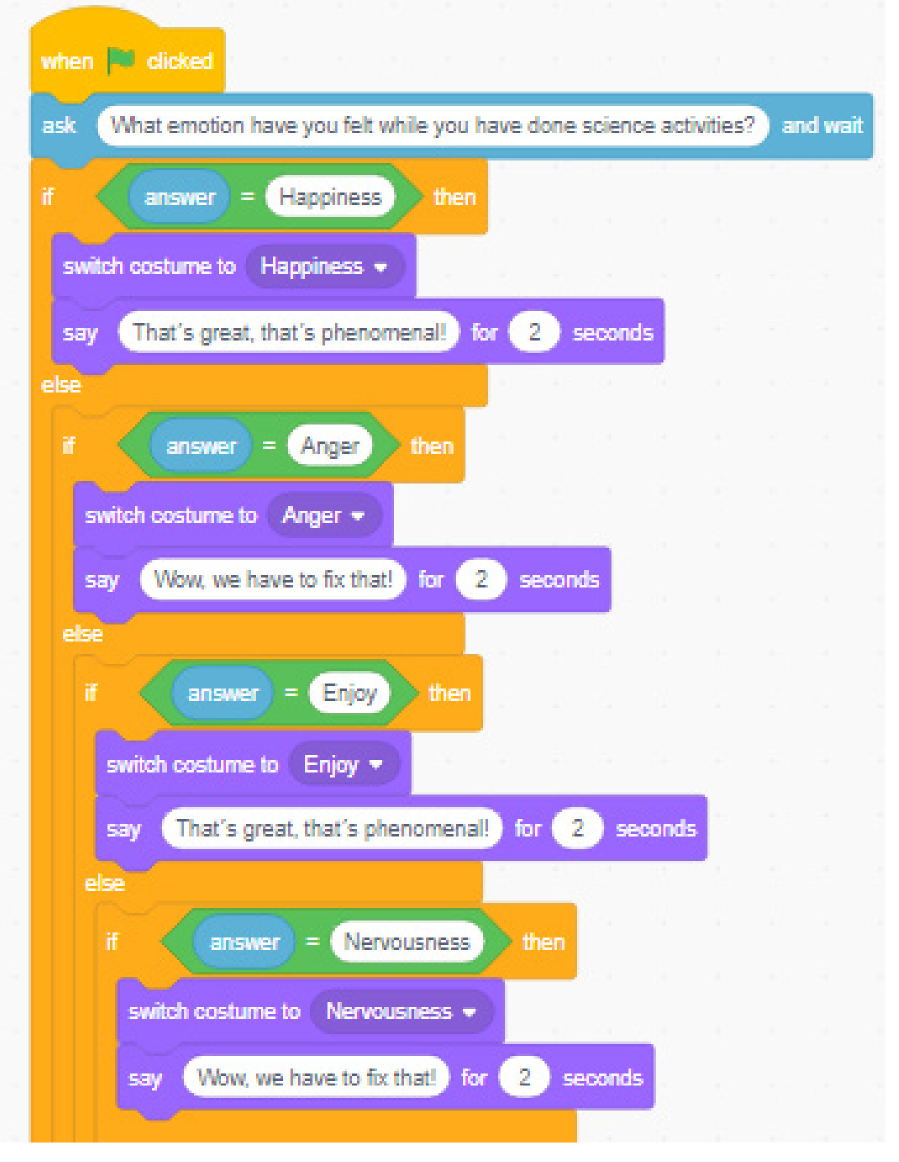
Figure 3
Board y tangible programming block



The use of these tangible programming blocks allows the students to work different CT skills that will be essential for later connected activities. The board also presents different variables that affect the sequence of unplugged programming, such as stop, repeat or more steps, which allows for increasing the difficulty and the development of CT skills in addition to the algorithmic sequence, such as repetitions or loops.

Figure 4 shows an example of the first activity, in which the Scratch® software is used to create questionnaires. The questionnaire aims to work with the full range of emotions that students reflect and to differentiate those emotions according to the discipline (Science and Mathematics) of learning. This makes it possible to analyze the emotions of each student individually, as well as to differentiate according to each content.

Figure 4
Scratch® programming of the questionnaire.

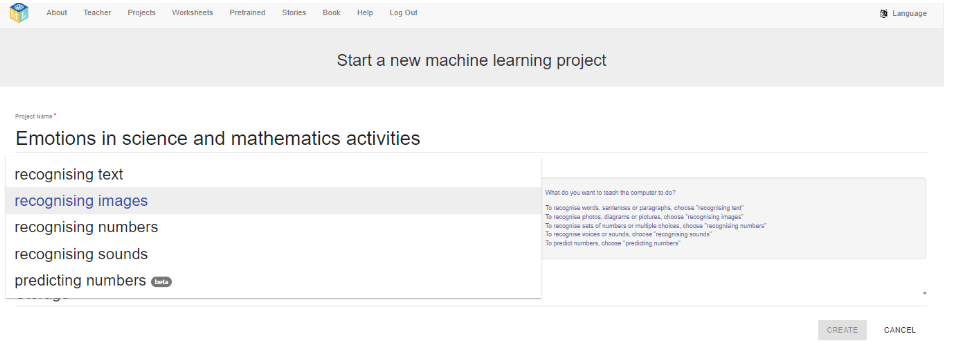


Regarding the programming, using the sensors function, we start with the question, "*What emotion have you felt while you have done science activities*?" or *"What emotion have you felt while you have done mathematics activities*?". Based on the question, conditions are set for each emotion. Depending on the student's response, a change in disguise is made to display the corresponding image that represents the expressed emotion, along with feedback for each emotion, such as "*That's great, that's phenomenal*" (if it is a positive emotion) or "*Wow, we have to fix that*" (if it is a negative emotion).

For the different expressions, students should take pictures of themselves, attempting to facially express each emotion. These pictures will then be used to appear on the screen according to the emotion selected, thus linking each emotion to a unique facial expression.

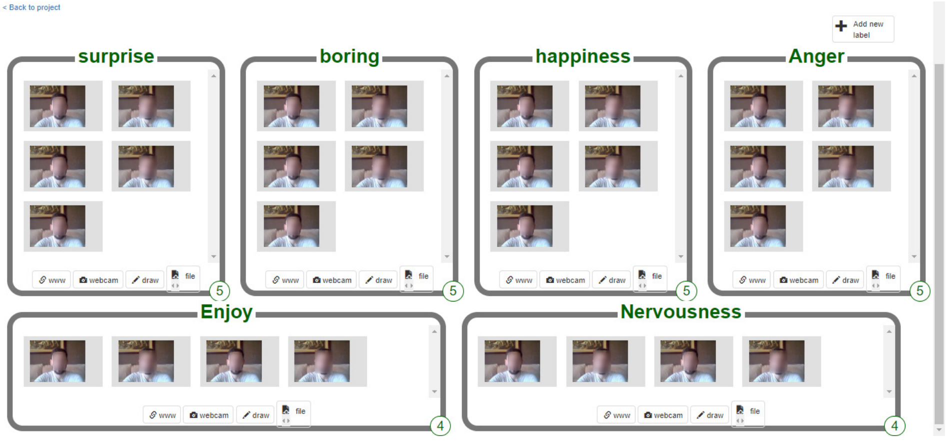
The subsequent activity builds on the work done in this first activity. First, the *Machine Learning for Kids* tool (Figure 5) is used to create a new project called "Emotions in Science and Mathematics". During the creation process, the source of information must be specified.Iin this case, images of the students are used, so image recognition is employed.

Figure 5
Creation of the Machine Learning for Kids project



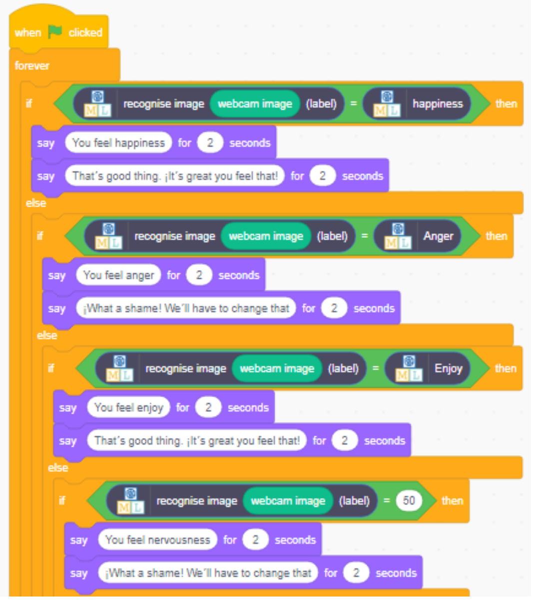
Once the project is created, AI must be trained for subsequent use. To do this, labels must be created for the different variables to be trained (Figure 6). For this proposal, the various emotions worked on in the first activity are used. To differentiate each emotion through image recognition, students must upload a variable number of images for each emotion (in this intervention, a minimum of 10 images is required). They can use the images taken in the first activity for each emotion and supplement them with additional ones using the webcam option.

Figure 6
Training to recognize emotions through images



Once this action is completed, *Machine Learning for Kids* offers the option to transfer the algorithm directly to Scratch®. Once in Scratch®, programming is carried out (Figure 7) to identify each labeled emotion based on the facial expression.

Figure 7
Programming to recognize emotion through facial expression.



In programming, conditionals are used again. In this case, a pairing code is created between the image recognition via the webcam and each of the emotions previously used. Similarly, for each emotion, a response is programmed so that the screen displays the emotion the student feels (e.g., *Feel happiness, Feel enjoyment*, etc.) along with feedback (e.g., *That's great! It's great that you feel that*, or *What a shame! We'll have to change that).* Additionally, the "Forever" control function is used to continuously update the recognition as the facial expression changes, allowing students to analyze different facial expressions and the corresponding recognized emotion in real time.

Discussion

The integration of innovative digital tools is an increasing requirement in education. Therefore, their introduction from the early educational stages is crucial for students to acquire the necessary skills tailored to the demands of both current and future societies (Bocconi et al., 2022). Under this paradigm, computational thinking skills take on a prominent role. To develop these skills, AI and ML are emerging as alternatives, having a significant impact on current educational institutions.

Recent studies demonstrate the mutual relationship between AI and CT skills (Hsu et al., 2023; Weng et al., 2024). In this context, AI and ML are already being introduced at various stages of higher education. However, there is still a lack of scientific evidence regarding their use in the earliest stages. A recent study by Weng et al. (Weng et al., 2024) indicates that 22% of the research has been conducted at the elementary education level, highlighting the need for more studies integrating AI and CT at this stage of education. Our study aims to support the integration of AI and ML in primary education, in alignment with the requirements of the neuroscientific disciplines of neurocognition and neuroeducation, which emphasize the importance of the affective domain content teaching. Specifically, previous studies have shown that science and mathematics disciplines often evoque a range of negative emotions (Blanco et al., 2010; Mellado et al., 2014), which is why this study focuses on the use of AI in activities related to these subjects.

The study outlines activities designed to introduce AI and ML in the third cycle of primary education. Initially, through an unplugged board activity, which serves as an introduction to the elements and skills of CT, students are later able to work with block programming and integrate ML and AI elements. Numerous studies have supported this initial approach using unplugged activities (Hsu et al., 2023; Weng et al., 2024; Chen et al., 2023), highlighting the importance of such activities before progressing to programming and the use of ML and AI.

Subsequently, two software (Scratch® and *Machine Learning for Kids*) are used. The first allows students to recognize emotions, while the second utilizes AI facial recognition to identify different facial expressions. Similarly, recent studies have employed block programming tools (especially Scratch®) and AI to teach science (Estevez et al., 2019) and mathematics (Zeng, 2013), as well as image-based programming to work on image recognition (Ríos et al., 2020).

In light of the above, it is clear that programs for emotional recognition and expression through AI and ML can be implemented in an accessible and tailored manner for primary school students, as recommended by previous studies (Vartiainen et al., 2021). In this regard, advances in neuroeducation and neurocognition highlight the importance of emotions in the learning process, particularly in scientific and mathematical disciplines (Mora, 2021). Therefore, the design of proposals that integrate the study of emotions during the learning of scientific and mathematical content, using tools such as programming and AI, aims to provide an innovative alternative and adapted to the demands of today's society.

Conclusion

In this paper, we propose a method for emotional recognition in primary school students that classifies emotions based on facial expressions. Unplugged activities, programming software, AI and ML such as Scratch® and *Machine Learning for Kids* are utilized. This study offers a particular approach to emotion recognition, using an accessible and non-specialized facial recognition programme, making it a simple alternative for implementation in various educational contexts.

The introduction of this proposal is based on complementary activities, beginning with an initial unplugged board and programming tasks that enable students to express the emotions that arise during science and mathematics activities, whether through human-computer interaction or non-digital means. Subsequently, the *Machine Learning for Kids* program is trained using different facial expressions. This is followed by a programming phase that enables the continuous recognition of students' emotions through facial expression analysis.

This study aims to contribute to the scientific literature by presenting activities that introduce AI and ML in elementary education for recognizing student's emotions through facial recognition. Additionally, these resources are used in training designed to enhance Computational Thinking skills from an early age.

Finally, this study advocates for an increase in research that incorporates these activities in early educational stages, integrating emotion recognition and the use of AI and ML from an early age.

Limitations and future lines of study

The study presents a proposal and the design of activities aimed at integrating the development of Computational Thinking skills and emotional engagement through the use of AI and ML. However, it is necessary to implement these activities and analyze their impact on students. Therefore, it is necessary to identify both the strengths and limitations of these activities when applied in educational practice. Their application with different groups of students, such as those with special educational needs—where emotional engagement holds particular scientific significance—would be highly relevant.

Finally, it is important to highlight the challenges that these types of activities may represent for teachers, particularly in terms of teacher training, as one of the major challenges in education today is the development of digital teaching competencies. In this regard, it is recommended to continue promoting such initiatives to support and guide teachers in their practical implementation.

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Declaration of interest statement

The authors declare no competing interests and this study was performed in line with the principles of the Declaration of Helsinki, and under the approval of the Bioethics and Biosafey Commission of the University of Extremadura (139//2023, on September 28, 2023).

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Alejandro De la Hoz Serrano
Department of Experimental Sciences and Mathematics Teaching Area,
Badajoz, Spain
Email: alexdlhoz@unex.es
ORCID: https://orcid.org/0000-0001-6362-3879

Lina Viviana Melo Niño
Department of Experimental Sciences and Mathematics Teaching Area,
Badajoz, Spain
Email: lvmelo@unex.es
ORCID: https://orcid.org/0000-0003-4771-058X

Miguel Ángel Martín Tardío
Department of Computer and Telematic Systems Engineering,
Mérida, Spain.
Email: matardio@unex.es
ORCID: https://orcid.org/0000-0002-2575-6934

João Piedade
UIDEF, Institute of Education of University of Lisbon, Lisbon, Portugal
Email: jmpiedade@ie.ulisboa.pt
ORCID: https://orcid.org/0000-0002-4118-397X

Florentina Cañada Cañada
Department of Experimental Sciences and Mathematics Teaching Area,
Badajoz, Spain
Email: flori@unex.es
ORCID: https://orcid.org/0000-0001-5544-0423

Javier Cubero Juánez
Department of Experimental Sciences and Mathematics Teaching Area,
Badajoz, Spain
Email: jcubero@unex.es
ORCID: https://orcid.org/0000-0003-1658-1041

Correspondência
Alejandro De la Hoz Serrano
Department of Experimental Sciences and Mathematics Teaching Area,
Badajoz, Spain. Avda. de Elvas, s/n. 06006

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