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# LETRAMENTO EM INTELIGÊNCIA ARTIFICIAL NO CONTEXTO DA EDUCAÇÃO MATEMÁTICA: UM ESTUDO EXPLORATÓRIO

## LITERACY IN ARTIFICIAL INTELLIGENCE IN THE CONTEXT OF MATHEMATICS EDUCATION: AN EXPLORATORY STUDY

## ALFABETIZACIÓN EN INTELIGENCIA ARTIFICIAL EN EL CONTEXTO DE LA EDUCACIÓN MATEMÁTICA: UN ESTUDIO EXPLORATORIO

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## Resumo

Este é um trabalho exploratório e interpretativo, construído a partir do estudo de artigos publicados por pesquisadores, que apresentam algumas implementações empíricas, documentos e propostas curriculares de governos e sociedades científicas sobre alfabetização em Inteligência Artificial (IA). Em vários países, esse campo de conhecimento está incluído nos currículos escolares, e os jovens devem receber esses conhecimentos desde o ensino fundamental. Essa abordagem é considerada alfabetização em IA. Os pesquisadores argumentam que a compreensão da IA, tanto integrada à tecnologia quanto centrada no usuário, é limitada. Assim, este estudo teve como objetivo identificar habilidades necessárias para a compreensão da IA que podem ser desenvolvidas no Ensino Fundamental, principalmente na Educação Matemática. Espera-se que as contribuições deste estudo orientem escolas e professores para a inclusão da alfabetização em IA, permitindo o aprofundamento do tema.

**Palavras-chave:** letramento, inteligência artificial, educação matemática.

## Abstract

This is an exploratory and interpretative work, built from the study of papers published by researchers, that present some empirical implementations, documents and curricular proposals from governments and scientific societies on literacy in Artificial Intelligence (AI). In several countries, this field of knowledge is included in school curricula, and young students are to be provided with this knowledge from elementary school. Such an approach is considered AI literacy. Researchers argue that an understanding of AI, both technology-integrated and user-centred, is limited. Thus, this study aimed to identify skills necessary for understanding AI that can be developed in Elementary School, especially in Mathematics Education. The contributions of this study are expected to guide schools and teachers towards including AI literacy, allowing the deepening of this theme.

**Keywords:** literacy, artificial intelligence, mathematics education.

## Resumen

Este es un trabajo exploratorio e interpretativo, construido a partir del estudio de artículos publicados por investigadores, que presentan algunas implementaciones empíricas, documentos y propuestas curriculares de

gobiernos y sociedades científicas sobre alfabetización en Inteligencia Artificial (IA). En varios países, este campo de conocimiento está incluido en los currículos escolares, y los jóvenes estudiantes deben recibir este conocimiento desde la escuela primaria. Tal enfoque se considera alfabetización en IA. Los investigadores argumentan que la comprensión de la IA, tanto la integrada en la tecnología como la centrada en el usuario, es limitada. Por lo tanto, este estudio tuvo como objetivo identificar las habilidades necesarias para comprender la IA que se pueden desarrollar en la escuela primaria, especialmente en la educación matemática. Se espera que las contribuciones de este estudio guíen a las escuelas y los docentes hacia la inclusión de la alfabetización en IA, lo que permitirá profundizar en este tema.

**Palabras-clave:** alfabetización, inteligencia artificial, educación matemática.

## 1 INTRODUCTION

According to UNESCO (2019), the development of Artificial Intelligence (AI) must be controlled by humans, centred on people and be at their service to improve their capabilities. AI must be designed ethically, in addition to being non-discriminatory, equitable, transparent, and verifiable. Its impact on people and society must be monitored and evaluated along value chains.

Even the most experienced specialists find it challenging to define AI in a manner that encompasses its notions, concepts, and purposes more thoroughly. There are some reasons for that, such as the one mentioned by Bostrom, who states that "a lot of cutting-edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough, it is not labelled AI anymore" (Luckin et al., 2016, p. 14). However, it is an interdisciplinary field with its own perspectives, terminologies, and in constant change (Arrieta *et al.*, 2020).

In this sense, AI would be a field that brings together:

> computer systems that have been designed to interact with the world through capabilities (for example, visual perception and speech recognition) and intelligent behaviours (for example, assessing the available information and then taking the most sensible action to achieve a stated goal) that we would think of as essentially human (Luckin et al., 2016, p. 14).

As an emerging technology, AI has revolutionised various societal actions (Kaufman, 2019, p. 90). However, researchers must understand how AI can impact human decisions (Ferreira & Monteiro, 2020). In this sense, while AI is becoming increasingly integrated into user-centred technology, people's understanding of these technologies is often limited. AI-powered virtual assistants like Amazon's Alexa, Apple's Siri, Microsoft's Cortana, and Google Assistant suggest products and services according to users' interests. AI applications expand to healthcare, finance, industry, education etc. For children, AI is present in different toys both for fun and with pedagogical potential. However, users are rarely aware that they are interacting with objects that use AI elements, and this limits their positioning as conscious consumers.

Thus, it is of paramount importance to investigate which skills, as considered by Montmollin (1990), the subject builds and modifies during their activities, such as the articulation of knowledge (declarative and procedural), representations, types of reasoning and cognitive strategies. Skills can be developed, from elementary school, so that users can interact with products and services and critically evaluate them, both currently and in the future. (Abrahão, Silvino, & Sarmet, 2005, p. 4).

As for evidence suggesting that AI literacy could improve elementary school mathematics education, Zhao, Wu, and Luo (2022) found that teachers' AI literacy, particularly their ability to apply AI, positively affected the effectiveness of class teaching. Kim et al. (2021) proposed an AI curriculum for elementary schools to cultivate students' AI literacy, focusing on three competencies: AI Knowledge, AI Skills, and AI Attitude. A meta-analysis of 21 studies found that AI had a small but positive effect on elementary students' mathematics achievement (Hwang, 2022). Han (2021) found that primary school teachers in Shanghai had a positive attitude towards the AI curriculum and were willing to apply it in their classes. Yet, he faced challenges such as limited instruction time and a need for more professional AI training.

These research papers suggest that AI literacy could benefit both teachers and students in elementary school education.

In a systematic research review, Celik et al. (2022) concluded that AI offers teachers several opportunities for improved planning, implementation, and assessment of their teaching; teachers have various roles in developing AI technology, such as acting as models for training AI algorithms and participating in AI development; and challenges in AI implementation in teaching practice provide guidelines for developing the field. With 428 teachers in Turkey, Celik (2023) developed the Intelligent-TPACK framework, a scale to measure the knowledge for instructional AI use based on the Technological, Pedagogical, and Content Knowledge (TPACK) framework, extending TPACK with ethical aspects. The findings indicated that, provided that teachers have more knowledge to interact with AI-based tools, they will have a better understanding of the AI pedagogical contributions. Accordingly, Technological Knowledge (TK) allows teachers to better assess the AI decisions. However, the educational integration of AI-based tools requires more than TK. For teachers to deploy AI in education efficiently, TK is meaningful when combined with Pedagogical Knowledge (PK), reflected in Technological Pedagogical Knowledge (TPK).

Some studies in the literature (Gadanidis, 2016; Hwang & Tu, 2021) indicate that some of these skills may be developed in the context of mathematics education. The research questions are: how to develop skills in elementary school for understanding Artificial Intelligence paradigms based on mathematical concepts? What should and can be taught to elementary to high school students in order to develop skills that bring them closer to AI-related skills? Can AI technologies created by learners promote their understanding?

One must consider that learning and training systems should equip people with basic skills in AI, including understanding how AI collects and can manipulate data, and abilities to ensure personal data security and protection (UNESCO, 2021, p. 2). Institutions responsible for education and those in charge of providing training must anticipate these changes, equipping today's workers and preparing new generations with the technical work and social skills needed to facilitate the transition to an AI-dominated world and ensure social sustainability.

The Beijing Consensus on Artificial Intelligence and Education indicates, among others, that:

- Teachers' roles and required competencies or skills, such as AI literacy, in the context of teacher policies, should be dynamically reviewed and defined; teacher training institutions should be strengthened; and appropriate capacity-building programs should be developed to prepare teachers to work effectively in AI-rich education settings.
- One should be aware of trends regarding the potential of AI to support learning and learning assessments, and curricula should be reviewed and adjusted to promote in-depth integration of AI and the transformation of learning methodologies. Applying available AI tools or developing innovative AI solutions where the benefits of AI use outweigh its risks should be considered in order to facilitate well-defined learning tasks in different subject areas and support the development of AI tools for interdisciplinary skills and competencies.
- AI tools should be applied or developed to support adaptive learning processes, leverage the potential of data to evaluate the multiple dimensions of students' competencies, and support large-scale and remote assessment (UNESCO, 2019, 32-33).

While several international organisations, such as UNESCO, the OECD (2021), and the World Bank, indicate Artificial Intelligence as a priority to be incorporated into teaching practice, teachers and students are suggested to be but simple users of AI systems, even though the European Commission has designed an intervention plan for education digitalisation as a goal for 2027, in which more active use of AI by teachers and researchers is intended (European Commission, 2021, 12).

We have justified this exploratory and interpretative study without empirical implementation, which will be improved based on papers published by researchers, and documents and curricular proposals from governments and scientific societies on literacy in Artificial Intelligence (AI). Also, this study aimed to identify skills necessary for understanding AI that can be developed in Elementary School, especially in Mathematics Education. The contributions of this study are expected to guide schools and teachers towards including AI literacy, allowing the deepening of this theme, as we present in the next section.

## 2 AI LITERACY

The original interpretation of the term literacy refers to the ability to express oneself and communicate using written language. In meeting these indications, AI literacy plays a key role because, according to Long and Magerko (2020), it can be understood as "a set of competencies that enables individuals to evaluate AI critically; communicate and collaborate effectively with AI, and consciously use AI in their daily lives" (Long & Magerko, 2020, pp. 4-7). These authors identify sixteen key competencies for understanding AI, and we have highlighted those with the most significant impact on Mathematics Education:

- Distinguishing between technological artefacts that use and do not use AI.
- Recognising many ways to think about and develop "intelligent" machines. Identifying various technologies that use AI, including technology spanning cognitive systems, robotics, and machine learning.
- Identifying problem types that AI excels at and problems that are more challenging for AI. Using this information to determine when it is appropriate to use AI and when to leverage human skills.
- Understanding what a knowledge representation is and describing some examples of knowledge representations.
- Recognising that humans play an important role in programming, choosing models, and fine-tuning AI systems.
- Understanding basic data literacy concepts.
- Understanding that data cannot be taken at face value and requires interpretation. Describing how the training examples provided in an initial dataset can affect the results of an algorithm.

How are these competencies being developed, and how are they being disseminated to the scientific community? Integrating these items into school curricula must be adapted to the age characteristics of students in each cycle and level of education. It can contribute to creating proposals for the development of AI literacy.

Like all areas of human knowledge, Mathematics Education has been strongly influenced by contemporary technologies, and in the study of mathematics contents, any of these competencies is present. Discussions about this process have been highlighted in research conducted in recent decades. They involve, from different theoretical perspectives, how software, networks, interactions in virtual environments and the use of other digital interfaces serve as a basis or somehow integrate didactic strategies for teaching and learning Mathematics. These may even constitute the repertoire of proposals to build initial or continued teacher training.

In Mathematics Education, AI can be considered a study and research subject through which specific knowledge of the area can be integrated to promote the development of adaptive learning environments (Gadanidis, 2016).

The first significant AI projects in the field of technologies for teaching Mathematics appeared in the early 1970s. It was Kimball's Integration Tutor (1973), in the area of Differential and Integral Calculus. This system, developed in a non-elementary domain, had the particularity of "being interested" in learners' solutions, even if they differed from those expected by the tutor (Balacheff, 1994, 5).

At the same time, the Logo project (Papert, 1980) appears and is considered one of the most important projects with theoretical specificities that take Mathematics explicitly into account (Hoyles, 1993 apud Balachef, 1994). This was widely used in Brazil and, in a way, inaugurated the use of software for teaching Mathematics.

Various other projects became known, but with little repercussion in Brazilian teaching, such as GEOMETRY-tutor (Anderson et al. 1985, apud Balachef, 1994) and WEST (Burton & Brown, 1979, apud Balacheff, 1994).

However, while they explicitly take mathematics as their object, these works need to truly consider the issue of the epistemological validity of the learning processes they support (Balacheff, 1994, 5). Some other studies have been developed and have influenced this context.

In a more recent study, Mohamed et al. (2022, p. 1), in a systematic literature review research, indicate that the AI approach used in mathematics education for the studied samples was through robotics, systems, tools, teaching agent, and autonomous agents, in a comprehensive approach. Types of AI topics in mathematics education were categorised into advantages and disadvantages, conceptual understanding, factors, role, idea suggestion, strategies, and effectiveness.



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## 3 STUDY PROCEDURES

This study is theoretical in nature. In this type of research, "empirical data and facts were not used to validate a thesis and a point of view, but a network of concepts and arguments was built with rigour and logical consistency" (Fiorentini & Lorenzato, 2009, p. 67, translation provided).

The research was developed through bibliographical studies, i.e., documental studies, which, according to Fiorentini and Lorenzato (2009, p. 102), are conducted on any written documentation. Information is collected using records of documentation readings that aim to organise the records related to the information obtained systematically.

For this case, we conducted bibliographic research. The first step is related to the search for documents and/or curricular indications in the literature that address the presentation of AI concepts in the educational system. A second one is related to Brazilian and Portuguese research associated with the use of AI in the field of Mathematics Education studies, to identify authors and Graduate Programs that are developing research in this field. Lastly, the third proposed step is in AI and Mathematics Education papers.

We used Content Analysis elements for the organisation and analysis of bibliographic research. This is understood, according to Bardin, as "a set of increasingly subtle methodological instruments in constant improvement, which are applied to extremely diversified 'discourses' (contents and continents)." (Bardin, 1977, p. 9, translation provided).

We believe that, through Content Analysis, it is possible to organise and collect data and to produce analysis that can help with the objectives proposed in this study, namely, to identify the necessary skills for understanding AI which can be developed by elementary school teachers. Content Analysis is:

[...] a set of document exploration techniques that seek to identify the main concepts or main themes addressed in a given text. (Oliveira et al., 2003, p. 6, translation provided).

Accordingly, we understand that, through Content Analysis, it will be possible to identify concepts that can help develop competencies to understand AI.

## FINAL REMARKS

Some projects have been developed with the GeoGebra application with Portuguese language countries working in tandem, involving initial steps for studying AI literacy, such as computational thinking, and showed important findings. The applications created contained variables that allowed the recording of student interactions, which could be exported to servers with the potential to audit data with artificial intelligence algorithms designed according to a hypothetical learning trajectory previously conducted by the teacher.

The findings proposed by the abovementioned projects, which introduced artificial intelligence techniques in learning development and management tasks, were used as a basis for this study.

With the production of the exposed research, we believe that we can indicate research trends related to AI and the Mathematics Education research field; identify some initiatives taken by other countries on the inclusion of AI elements in Elementary School; and, lastly, map digital resources (or not) and activities to assist in the development of AI literacy.

We understand that developing a study of this nature allows highlighting AI concepts that can be used by Elementary School teachers and academic papers that recommend the inclusion of AI in Elementary School to indicate research trends in Mathematics Education.

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