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Integrating Artificial Intelligence into High-School Computer Science Curriculum: A Perspective Study in Morocco

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ABSTRACT
With the proliferation of artificial intelligence (AI) across various global industries, it has become necessary to introduce AI education in pre-tertiary curricula. This topic has started to gain serious attention in many countries, with numerous real-world initiatives emerging. However, in developing countries, notably Morocco, this topic is rarely addressed in the literature, and relevant initiatives are virtually nonexistent, to our knowledge. This paper aims to fill this gap by presenting a perspective study on the integration of AI into the computer science (CS) curriculum in Moroccan high schools. Specifically, the paper i) highlights international initiatives in AI education as well as the current state of AI education in Morocco; ii) evaluates the current CS curriculum in Morocco, emphasizing its weaknesses and calling for a comprehensive review that incorporates AI teaching; iii) argues for the integration of AI into the high-school CS curriculum; iv) recommends and discusses specific approaches for stakeholders in the education field to consider; v) explores critical challenges and considerations that could hinder this; and vi) provides practical tools and resources to facilitate AI education in Moroccan schools.

KEYWORDS
Artificial intelligence; pre-tertiary education; computer science curriculum; Moroccan educational system.

INTRODUCTION

Artificial intelligence (AI) has recently gained significant attention as one of the most fast-growing fields globally (Lu, 2019; Mabungela, 2023; Vargas et al., 2024). AI seeks to develop systems capable of making decisions autonomously based on data gathered from prior experiences. This has been enabled by the increased computational power of modern devices and the availability of huge amounts of data. Currently, AI has demonstrated exceptional performance in various sectors, often surpassing human capabilities in areas requiring precision and data analysis (Douali et al., 2022). Its widespread applications, including in social networking sites, self-driven cars, chatbots, and search engines, illustrates its transformative impact on multiple aspects of daily life (Shalev-Shwartz & Ben-David, 2014). The European Commission has recognized AI as one of the most promising technologies of the 21st century, emphasizing the need for more AI-skilled individuals in the future labor market (European Commission, 2018).

In this new era, a basic understanding of AI is increasingly essential for individuals to navigate the “new normal.” Recognizing this, educational institutions worldwide have begun incorporating AI education into their curricula, enabling students to gain foundational understanding of AI and participate in the digital economy (Kim et al., 2021). Kahn et al. (2018) outlined four main benefits of AI education: i) enhancing motivation and self-efficacy; ii) understanding perception, reasoning, psychology, and behavior; iii) acquiring knowledge of up-to-date technologies; and iv) engaging in critical reflection of one’s skills. Although research on AI education remains relatively nascent compared with other fields, a growing number of initiatives and studies have emerged, many of which highlight the urgent need to integrate AI into pre-tertiary education (Central Board of Secondary Education, India, 2019; Fengchun et al., 2021; Knox, 2020; Touretzky et al., 2019).

In Morocco, higher education has taken significant steps in teaching AI. For instance, a new module called "power skills," which includes "digital skills" and integrates AI education, has been introduced across various academic branches, including fields apart from science and technology. Furthermore, specialized AI schools have started to emerge. However, at the pre-tertiary level, particularly in high schools, AI education remains largely overlooked by policymakers, and discussions on this topic are scarce. The Moroccan education system is structured into primary schools starting from ages 6 to 12, middle school from ages 12 to 15, and high school from ages 15 to 18. High school is further divided into a common core year and specialization tracks in the final two years, preparing students for college or employment. Despite these developments, no official initiatives have been undertaken to introduce AI into the high-school computer science (CS) curriculum (Douali et al., 2022; Kumar et al., 2023). Additionally, research exploring AI integration as educational material in the Moroccan context is lacking. Addressing this gap could encourage policymakers to take AI education more seriously and approach it more actively.

Contributions

This paper aims to contribute to filling this gap by presenting a perspective study on the integration of AI into the high-school CS curriculum in Morocco. The primary goal is to lay a foundation to guide further developments in this field. For this reason, we provide a critical analysis of the current CS curriculum, which highlights its shortcomings, like the lack of coherence, inadequate resources, and stagnation. We also evaluate the current global status of AI teaching/learning as well as the status of AI education in Morocco. From these assessments, we call for a fundamental change in the CS education curriculum that must incorporate AI instruction. We suggest possible strategies for AI integration into the high-school curriculum. These strategies are critically analyzed to show their strengths and limitations. We also present the issues to be considered for proper integration. To avoid limiting the discussion to a theoretical level, we bring to light several free practical tools and materials that can be employed in teaching/learning AI in a classroom setting. The main contributions of this article can be summarized as follows:

- Presenting an overview of the international efforts on AI integration in pre-tertiary education systems as a learning material, as well as the status of AI education in Morocco.
- Reviewing the Moroccan CS curriculum, providing its main features and limitations.
- Presenting arguments, pathways, concerns, and resources to help facilitate the successful AI integration into the CS curriculum.

METHOD AND ORGANIZATION

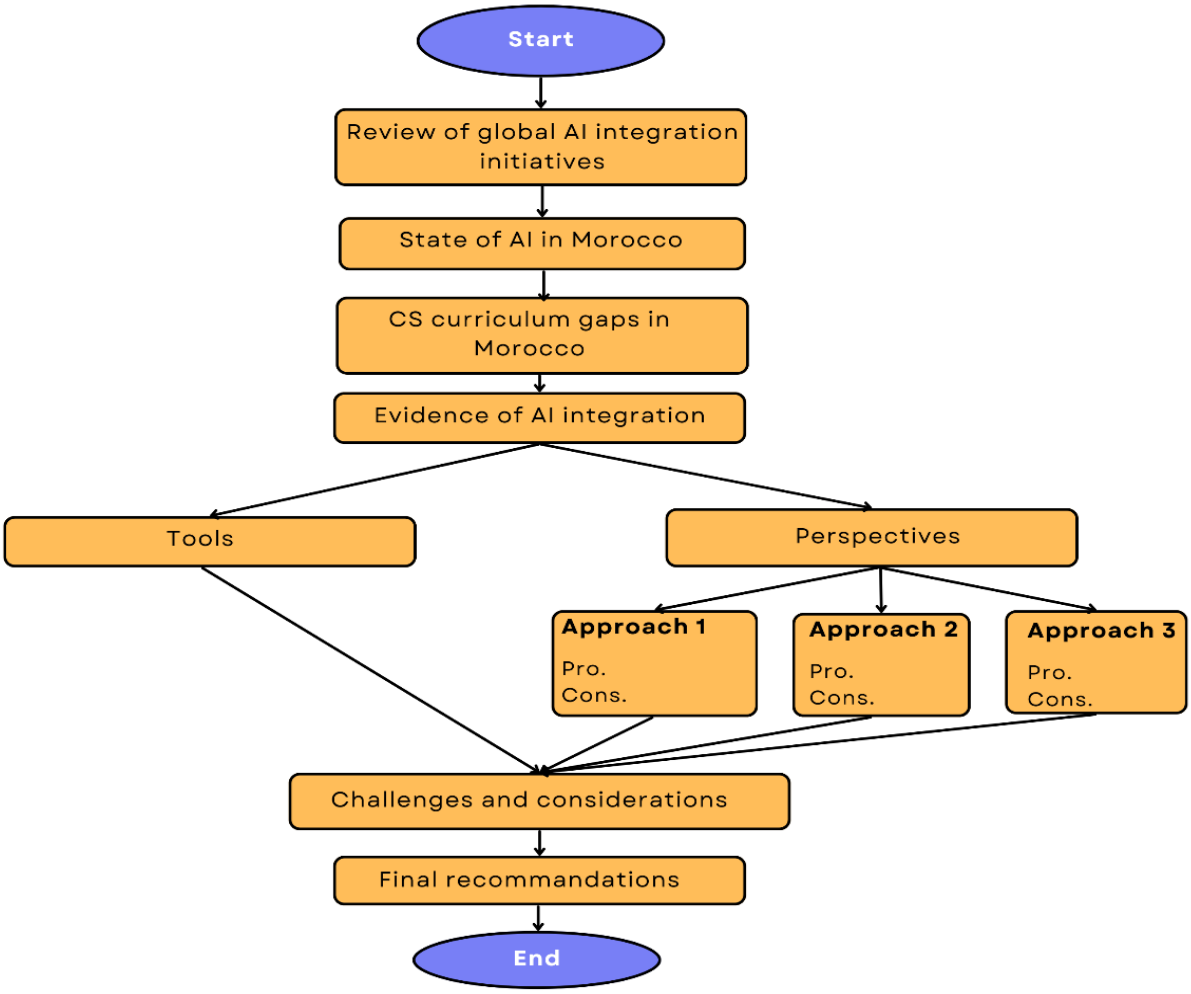
Given the lack of specific guidelines for prospective studies, we adopted a structured methodology tailored to our research objectives. First, we reviewed global efforts to integrate AI into pre-tertiary education to identify international trends and perspectives. Second, we analyzed the current state of AI education in Morocco, identifying gaps and inadequacies. Third, we examined the Moroccan CS curriculum to pinpoint its specific deficiencies.

Based on these analyses, we proposed three feasible approaches for integrating AI into the high-school curriculum, discussing their advantages and limitations. To facilitate implementation, we identified practical tools and resources aligned with these approaches. We also highlighted potential challenges and offered recommendations to help stakeholders promote AI education in Moroccan schools.

The paper is organized as follows: Section 2 reviews international efforts that have been made to incorporate AI into education systems. Section 3 focuses on the current status of AI education in Moroccan schools. Section 4 reviews the current CS curriculum in Morocco. Section 5 discusses how this curriculum could incorporate AI. Finally, Section 6 concludes with the final remarks of the paper.

Figure 1.

Flowchart of the proposed research method



BACKGROUND

Global Trends in Introducing AI to Pre-University Education

Given the increasing penetration of AI in almost all spheres of social and economic life, it is essential for individuals to possess at least a basic awareness of AI (Alonso, 2020). This necessitates the enhancement of AI literacy among the public to enable them to integrate into an increasingly digital world (Estevez et al., 2019; Stone et al., 2022). AI literacy is necessary to prepare the future generations for developing positive relationships with emerging AI technologies. According to Kim et al. (2021), achieving AI literacy involves three main competencies: AI knowledge, AI skills, and AI attitude. AI knowledge encompasses the ability to define what is AI, understand the different techniques used in AI, and recognize the various categories of AI applications. AI skills entail computational thinking and programming skills to manipulate tools, solve problems, and create simple applications with the help of AI. AI attitude corresponds to specific aspects based on students' understanding of societal and ethical aspects surrounding AI.

Recognizing the need to raise AI literacy, research in the field of AI education is expanding. Recent studies recommend offering AI education not only at the university level but also at the primary- and secondary stages. While higher education focuses on enhancing AI expertise among academics and future professionals, the pre-tertiary stage should aim at increasing AI awareness among young individuals (Kim et al., 2021). This can be achieved by familiarizing students with the basics of AI through accessible methods such tools as interactive lessons, projects, and games. Accessible teaching methods can introduce AI concepts such as pattern recognition, machine learning, natural language processing, and AI applications. Research suggest that high school, particularly at the age of 15-18 years, is the most suitable stage for AI education because students at this stage typically possess the necessary digital and mathematical skills, allowing for immediate results (Bellas et al., 2023).

Numerous global initiatives have emerged recently to integrate AI instruction into pre-tertiary education curricula (Bellas et al., 2023). In 2021, UNESCO published an important report on K-12 AI curricula (Fengchun et al., 2021), aiming to lay the groundwork for structured AI education integration. The report offers important guidelines for policymakers and curriculum developers worldwide to effectively incorporate AI into pre-tertiary education.

Another notable initiative, AI4K12, was launched by researchers and experts from the USA (Touretzky et al., 2019). The project had three main objectives: i) adopting a national guideline for teaching AI; ii) creating an online repository of AI educational resources; and iii) forming a group of scholars and practitioners in education and computer science to improve AI teaching in pre-tertiary education. To implement a new approach to AI teaching, the initiative calls for cooperation among multiple stakeholders, which would lead to the development of a standardized AI curriculum with a solid theoretical and methodological foundation. The project team identified five core ideas in AI education: i) Computers interact through sensors; ii) AI can represent the external environment; iii) Machines learn from data; iv) issues related to interactions between humans and agents; v) social and ethical implications of AI. These ideas are vital not only for those creating curricula but also for educators and schools that aim to teach AI as a separate subject.

Several countries worldwide have begun incorporating AI into the learning process. For example, the British Parliament has acted as a pioneer in this regard by recommending that AI education be introduced in high schools (Select Committee on Artificial Intelligence, 2018). China followed suit in 2019 by implementing AI education in middle- and high schools (Knox, 2020), while South Korea has included AI subjects in high schools since 2021 (Kim, 2023). In India, AI education has been officially launched in 200 secondary schools (Central Board of Secondary Education, India, 2019), with plans for expansion. In Australia, authorities partnered with IBM to introduce a the “Digital Technologies Education” project for K-12 students (*Partnership Profile*, 2020), aimed at integrating AI education into secondary schools.

In addition to national approaches, many papers in the literature have proposed frameworks for structuring AI teaching and implementing AI curricula in pre-tertiary education. Sabuncuoglu

(2020) suggested an AI curriculum that emphasizes the interdisciplinary nature of the field, incorporating aspects related to sociology, physics, and biology. The curriculum begins with the definition of AI and its various applications, then introduces three key modules: i) how computers communicate: designing interfaces; ii) how computers see: computer vision; and iii) how computers listen: audio applications. All modules align with the five big ideas outlined by Touretzky et al. (2019), reflecting the diverse aspects of AI.

To develop a pre-tertiary AI curriculum, Chiu et al. (2022), implemented the AI4Future project at The Chinese University of Hong Kong. This project involved AI experts, pedagogical specialists, and practitioners. Their collaborative effort led to the creation of a high-school AI curriculum with 12 chapters, addressing topics ranging from awareness to empowerment, including foundational concepts in chapters 1 and 2, AI domains such as computer vision and speech processing in chapters 3–9, discussions on societal implications, ethical considerations, and future transformations in chapters 10-12. The curriculum is flexible, allowing educators to tailor the content to their conditions and objectives. The project outcomes revealed two key findings: i) students acquired improved skills and developed favorable attitudes toward AI education, and ii) teachers enhanced their own AI knowledge.

AI curriculum implementation has garnered interest in the literature. However, most proposed curricula are tailored to specific educational contexts or levels (Chiu et al., 2022; Lee et al., 2021; Yang, 2022). Given the organizational differences between regions and countries, implementing universal approaches remains a challenge. Another critical issue is the active involvement of all stakeholders in education. Developing formal AI curricula demands collaborative efforts from AI experts, CS professionals, educators, policymakers, and others. This collaboration ensures alignment between the educational objectives, student needs, and their capabilities.

Current Status of AI Education in Morocco

Morocco has made significant strides in AI integration across various sectors. Higher education is one of the sectors that has seen improvements and an increased adoption of advanced technologies, such as AI (Marouane et al., 2021). Several measures indicate that policymakers are keen on deploying AI in higher education. These measures include the establishment of AI-specialized schools in many Moroccan cities. For instance, the Euromed School of Digital Engineering is one of the first AI-focused schools in Africa. Additionally, most universities have shifted toward prioritizing AI instruction and research. It is also worth noting that AI courses are integrated into various fields, not just in scientific and technological disciplines. In a recent reform, the Moroccan Ministry of Higher Education introduced a module called "Power Skills," which includes a component focused on "digital skills," aimed at enhancing AI literacy among students. Furthermore, there has been an increase in AI-related events such as conferences, workshops, and summer and autumn schools. Lastly, Moroccan institutions have begun to engage in international collaborations in AI, with examples like the International University of

Rabat participating in multifaceted projects such as cyber-attack prediction, robotics, and self-driving cars.

However, progress in higher education is not the same as in pre-tertiary education regarding AI education. Despite advancements in higher education, there has been no official effort thus far to integrate AI into pre-tertiary curricula. Research in the Moroccan context on AI as teaching material as also scarce. Nevertheless, some studies are relevant to this topic. For instance, Douali et al. (2022) explored Moroccans' perceptions, aspirations, and concerns about AI integration into education. They conducted a survey with 336 participants from different educational backgrounds across various Moroccan regions. The study's findings revealed increased concerns about AI's implications, especially in early education, along with cautious optimism about its potential to assist in teaching tasks. In another study, El Bakkouri & Raki (2023) examined student feedback on AI-powered virtual assistants in Moroccan educational settings. The findings indicated a generally positive attitude from students, who found the assistants helpful, although some expressed disappointment with the interactions, indicating that these assistants require more customization and improved response quality. In a related study, Falah and Noreddine (2017) proposed integrating robots as learning tools into the Moroccan educational system, offering a practical framework for teaching robotics in pre-tertiary education.

Current Structure of the Moroccan CS Curriculum

CS education has been formally introduced as a subject in school curricula across many countries, reflecting its growing importance in modern learning paradigms. However, CS education varies by country due to differences in pedagogical approaches and educational contexts. Ongoing discussions focus on the dynamic nature of information technologies and the need to update educational curricula to elevate CS education to the level of traditional disciplines such as mathematics and natural sciences (Ouahbi et al., 2019).

Morocco has recognized the critical need for CS integration to secure its future (Farhaoui, 2017). The CS integration policy began in the 1980s and was further strengthened by the introduction of the National Charter for Education and Training in 2000 (Belfkih, 2000). In 2005, the Ministry of Education launched the GENIE (Generalization of Information Technology in Education) program, aimed at spreading Information and Communication Technologies (ICT) in education. Since then, the GENIE project has continued to focus mainly on training educators, and equipping infrastructures with technological material (Falah & Noreddine, 2017). This policy is also reflected in the strategic vision for education from 2015 to 2030, which emphasizes the active role of ICT in education to help integrate young learners into the economy and knowledge society (Moroccan Governement, 2020). Recent government efforts, such as the introduction of Scratch and Minecraft in elementary and secondary school settings, align with this policy (Iqdour et al., 2021).

Officially, CS is introduced in secondary school curricula (middle and high schools), but it is absent in primary schools. In middle school, the CS curriculum focuses on familiarizing

students with ICT and introducing programming concepts. In high school, CS is part of the first year for all branches (Common Core). However, in the second and third years, CS is neglected, except in the technological and economic branches, where CS is still included (Department of Moroccan National Education, 2005). The high-school CS curriculum also focuses on ICT applications and programming but with more depth compared with middle school. In the common core, the CS program is organized into four modules that address both theoretical and practical aspects of the discipline. Table 1 outlines the main objectives and skills of the CS program at the common core level, while Table 2 describes the content of the modules. Table 3 provides information about the evaluation procedures in the CS program. All data are sourced from official CS education documentation in Morocco (Department of Moroccan National Education, 2005).

CS education in Morocco faces several limitations, the main ones being:

- CS courses are absent in primary education, either in schools or official documents. ICT integration is limited to individual initiatives. Notably, some private institutions offer CS courses to attract students (Oumad et al., 2023).
- In middle school, official guidelines state that students should receive two hours of CS education per week, but most students only receive one hour due to resource shortages and the need to work in rotation settings. Additionally, CS education is often limited to the second year, contrary to official guidelines that advocate for CS learning across all middle school years (Haddi, 2009).
- In high school, CS education is limited to the common core, which does not align with the growing recognition of ICT's importance and the policies supporting ICT integration (Haddi, 2009).
- The lack of continuity and consistency in the CS curricula across middle- and high-school levels. There is a clear lack of progression in terms of difficulty, depth, and thematic coherence.
- The proposed CS program overlooks students' existing digital literacy, which could reduce their interest in CS courses.
- At the high-school level, there is misalignment between the CS program and its intended objectives. For example, the algorithmic and programming module is taught in only 16 hours, which is deemed insufficient (Ouahbi et al., 2019). Additionally, the network and internet module receives limited attention due to a lack of network equipment and its placement at the end of the program.
- The CS curriculum has not been updated since its introduction in 2005. Given the rapidly evolving nature of CS, the curriculum must be revised periodically to avoid teaching

outdated material that no longer meets the needs of young learners. Furthermore, the curriculum lacks periodic evaluations to ensure its quality (Oumad et al., 2023).

Table 1.

The purposes and skills of the CS Curriculum of the common core

Purposes	Skills
• **Pedagogical**: This teaching provides access to the Sciences and allows the acquisition of knowledge and independence. • **Scientific**, in that this discipline is recognized as an academic subject, transversal in comparison with languages, Fundamental rather than optional. • **Professional**, as CS has already migrated to an indispensable technology necessary for any profession in the future.	• Utilize the component of an operating system to manipulate (create, find, remove, duplicate, transfer, group, rename, …) documents (files and folders). • Use the available features of a word processor and create a document with tables and possibly graphic objects. • Employ the distinctive of a spreadsheet processor to create a spreadsheet. • Plot data from a simple statistical distribution into a graph. • Employ the main Internet services to attend and retrieve information as well as to communicate synchronously and asynchronously. • List hardware and software elements of a Computer Network. • Choose an algorithmic solution for a problem that is to be solved. • Convert an algorithm into a high-level language to be used in computer programming.

Table 2.

Content of the CS curriculum of the Common Core

Module	Content
Overview of Computer Systems (8h)	• Definitions and Basic Vocabulary (2h) • Basic Structure of a Computer (4h) • Types of Software (1h) • Application domains (1h)
Software (22h)	• Operating System (6h) • Text processing software (10 h) • Spreadsheet software(6h)
Algorithmics and programming (16h)	• Basic algorithm concepts (4h) • Basic control structures (6h) • Programming languages (6h)
Networks & Internet (14h)	• Basic IT network concepts (4h) • Internet network (10h)

Table 3.

Evaluation settings in the CS curriculum of the Common Core

What to evaluate	When to evaluate	How to evaluate
• The proper and rational utilization of the available software tools to develop a solution or product. • Reasoned and autonomous employing computer hardware • The proper and rational utilization of the available software tools to develop a solution or product.	• During the pedagogical sequence for setting up a framework to handle errors that might occur in new learning (1 hour) • At the end of a pedagogical module validate competencies and certify learning. (1 hour)	• Theoretical • Practical • Schedule, approach, and responsibility in the completion of a mini-project

MAIN PERSPECTIVES

Evidence

In this section, we argue for the necessity of AI integration into the CS curriculum of high schools in Morocco. To support this argument, we present several points listed below:

- The interdisciplinary nature of AI, which incorporates concepts from perception, reasoning, psychology, and behavior (Kahn et al., 2018), may help stimulate interest in this topic among students. This may also broaden their knowledge of these related AI is currently the most innovative technology known, and learning AI will prepare students to become relevant members of the global society. It will also enable students to contribute positively to the enhancement of society's technological platforms.
- AI education will help train future generations for the evolving job market, which is increasingly incorporating AI technologies across various professions.
- Moroccan higher education has already integrated AI instruction, and the number of AI-focused institutions is growing. Including AI in the high-school curriculum will better prepare students to pursue further education in AI-related fields.
- There is a need to introduce AI education to young people to raise awareness of the benefits, challenges, and ethical issues AI brings to society. This will help develop moral reasoning and the responsible use of these technologies.
- AI education may help sharpen students' computational thinking, a valuable skill in this IT-oriented age (Papert, 1980).
- Understanding AI techniques may enhance students' innovation and creativity by opening new possibilities and outcomes.

Proposed Approaches

It is widely agreed that AI integration into the CS curriculum requires a multi-stakeholder approach, involving scholars in education, AI, CS, policymakers, and other relevant actors (Sabuncuoglu, 2020). This integration requires a complete review of the existing CS curriculum, along with processes such as teacher training and providing institutions with the necessary tools. In this section, we propose three potential strategies for AI implementation, considering the features of the current CS curriculum and the resources available in Morocco's diverse educational environments.

Approach 1: The first approach involves adding a separate AI module to the CS curriculum of the common core. Introducing a comprehensive AI module, covering various aspects of AI, would provide students with a general understanding of its fundamentals, uses, and consequences. As mentioned earlier, the CS curriculum consists of four modules, so the AI module could be added as a fifth module or integrated with the algorithmic and programming module. However, changes to the time allocation for the modules will be necessary to accommodate the 68 hours of the entire CS program, depending on the chosen approach.

Approach 2: The second approach suggests introducing AI concepts within the existing modules without altering the overall structure or time frame of the program. This approach assumes that AI is interconnected with various fields. Consequently, AI fundamentals and applications can be integrated into CS modules such as programming, networks, systems, and software. By embedding AI into different components of the curriculum, students will gain insight into how AI can be applied across various fields. This approach ensures that AI is taught throughout the year and emphasizes its relevance as one of today's most emerging technologies.

Approach 3: The third approach advocates for extending CS education throughout all high-school levels. This would require a complete overhaul of the current system, which may be costly in terms of time and financial resources. Significant investment would be needed for teacher training, the provision of classrooms equipped with appropriate technology, and other teaching aids. However, this approach would offer more opportunities to introduce modules on AI and other modern technologies like cloud computing, big data, and cybersecurity. As a result, students would enhance their digital competencies and understanding of these technologies. While this approach may be expensive, it would ensure the most efficient implementation of AI in education. Table 4 compares the three proposed approaches, listing their pros and cons.

Table 4.

Advantages and limitations of the proposed approaches

Approach	Advantages	limitations
Approach 1: Separate AI module	• Targeted learning: In a separate AI module, learning can be unique and central, which goes in line with the ever-changing nature of AI. • Cost-effectiveness: The addition of an isolated AI module within the current CS program is less expensive than implementing another curriculum for AI. • Minimal reform efforts: having an independent AI module does not require profound changes in the entire curriculum.	• Time constraints: The introduction of an independent AI module might have difficulties in the time constraints that can be offered to the curriculum. • Challenges in interdisciplinary application: The knowledge acquired can be limited, which may limit the capacity of students to understand the relationship between AI and other CS areas. • Curriculum Overload: the existing CS program is already heavy and therefore, adding an extra module may imply reducing the other modules' content to avoid overload.
Approach 2: AI concepts inside the existing modules	• Holistic Learning: The incorporation of AI inside the other modules enables the students to learn AI concepts related to each of the CS disciplines. • Efficiency: the necessity to add an extra module may save us more time. • The incorporation of AI concepts is also easy to do within existing modules in that there is little need for modifications to the program's structure and/or assessment strategies.	• Since the time allotted to each of the modules is rather limited even as it is, condensing several ideas within them may lead to qualitative degradation of the learning process and prevent proper understanding of the material. • Understanding the relationships between certain modules and AI, as well as determining what aspect of AI is linked with the specific modules might prove to be a major challenge during integration. • Superficial Understanding: As it may be easy to elaborate and proven to be cost-effective this approach is likely to leave students with a rather shallow understanding of the AI field.
Approach 3: Broadening CS curriculum across high school levels	• Comprehensive Exposure: Extending the CS program will guarantee more exposure to today's technologies. • Deeper Understanding: Allocating a reasonable amount of time to learn about AI will enable a better understanding.	• Costly Implementation: This entails huge financial investments to purchase technology-related commodities and develop course infrastructure and staff with an adequate number of qualified educators. • Time-Intensive Adaptation: Integrating CS and AI across all the high school levels may take a long period.

Tools and Resources

One of the most popular methods for teaching AI is through visual programming tools (Rose et al., 2017). These tools feature visual interfaces that greatly improve students' understanding of programming concepts without requiring prior experience. Scratch is one of the most widely tools for this purpose. It has been proven to increase student engagement and motivation to learn programming skills (Malan & Leitner, 2007). With its user-friendly interface, Scratch could become an exciting tool for AI learning and help students grasp the basics of computational thinking in AI processes (Estevez et al., 2019). Scratch is available in more than 40 languages, making it suitable for implementation in educational systems worldwide. To date, it has been adopted by more than 150 educational institutions globally (Alonso, 2020).

Another alternative that could be used efficiently to teach AI is Intelligent Tutoring Systems (ITS). ITS is a field of study that focuses on creating educational systems that offer individualized teaching strategies tailored to the learner's learning needs (Niño-Rojas et al., 2023). In general, ITS are designed to provide personalized support and feedback, enabling students to learn at their own pace (Hibbi, 2024). ITS differ from other educational systems, particularly from Computer Assisted Instruction (CAI), as described by VanLehn 92006). Unlike CAI, ITS can observe learners' problem-solving processes and respond immediately. Recently, the term ITS has replaced intelligent CAI. A study by Hibbi et al. (2021) showed that the use of this tool helped 72.73% of learners in AI programming, fostering analytical and problem-solving skills and promoting independent learning among young learners in Morocco. This demonstrates the usefulness of ITS in assisting teachers with AI teaching in pre-tertiary education.

AI education can also be approached using pedagogical robots. Research indicates that robotics engages students and sparks interest, motivating them to pursue math and science careers (Mauch, 2001). Studies have also demonstrated that robotic education enables students acquire broader skills (Cielniak et al., 2013). Many countries have now integrated educational robots into their curricula. Robotics workshops are particularly effective in teaching coding to young students via platforms that use graphical interfaces and software, which aligns with experiential learning and constructivist theory (Alimisis, 2012) (Eguchi, 2015). While robotics can help in teaching AI—-such as using low-cost robot platforms to demonstrate neural network training for robotic navigation (Greenwald & Artz, 2004)—it is important to emphasize the distinction between robotics and AI concepts, to avoid confusion among students.

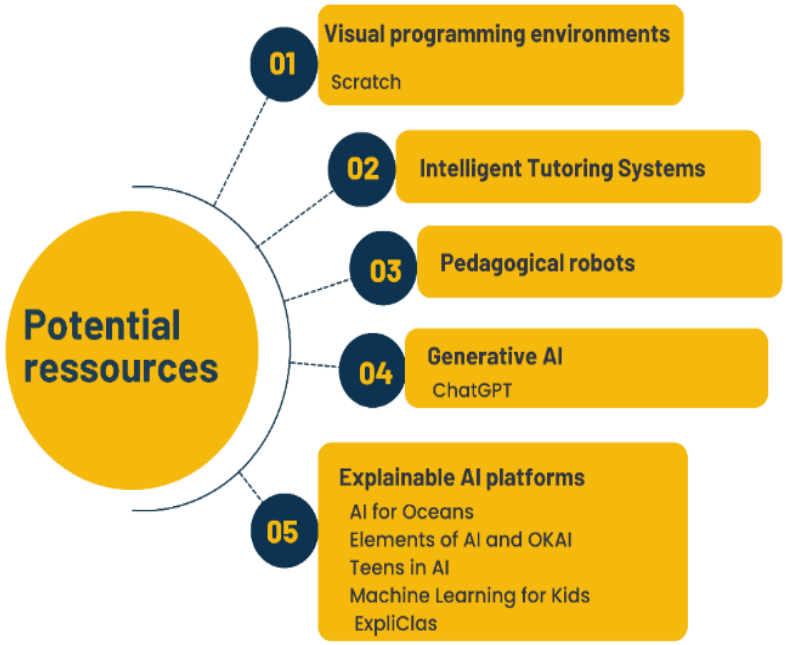
Generative AI, such as ChatGPT and Gemini, can be a highly effective educational tool when teachers understand its basic concepts. These technologies can be integrated into various classroom activities, creating learning environments that foster critical and metacognitive thinking. Language model systems can produce human-like text and respond to queries raised during the learning process, making the process interactive and human-like. This interactivity not only encourages critical thinking but also supports individualized learning, as responses are based on the input provided.

Moreover, the number of tools available to the public for learning AI has increased, targeting a wide range of age groups. Educators can incorporate these tools into their classes. Notable examples include:

- A two-hour activity, "AI for Oceans[1]" gamified by Code.org, which focuses on the basics of AI and aims to equip participants with essential knowledge.
- Platforms like “Elements of AI[2]” and “OKAI[3]”, designed to teach the public about AI development and capabilities.
- The "Teens in AI[4]" program, which includes hackathons, boot camps, and mentorship to encourage AI education for teenagers.
- The "Machine Learning for Kids[5]" platform, which helps children learn about AI systems and create games in Scratch.
- Explainable AI projects such as ExpliClas[6] (Alonso & Bugarín, 2019), which promote accountable and transparent intelligent systems that are essential for human engagement.

Figure 2.

Potential tools and resources for AI education



Although these projects help bridge the gap between cutting-edge AI research and public knowledge, it should be noted that such initiatives sometimes overshadow the importance of

[1] https://code.org/oceans

[2] https://www.elementsofai.com/

[3] https://okai.brown.edu/index.html

[4] https://www.teensinai.com/

[5] https://machinelearningforkids.co.uk

[6] https://demos.citius.usc.es/ExpliClas/datasets

foundational science disciplines that underpin AI knowledge and its applications (Sabuncuoglu, 2020). Additionally, these initiatives often focus on individual topics, which limits the understanding of the broader context of AI applications and development (Sabuncuoglu, 2020). Education stakeholders must address these drawbacks to ensure successful AI integration into the educational structure. **Error! Reference source not found.** summarizes the tools covered in this section.

Challenges and considerations

The most difficult challenge in AI integration is the attitude of teachers toward AI and their concerns regarding it. The level of integration is highly dependent on the perception and approval of educators. However, despite this newly emerging field of AI, there is still a lack of understanding of how teachers perceive it (Sanusi et al., 2022). In countries like Morocco, where research on AI in education is minimal, more research is needed. Global studies have found that some teachers are afraid of or uncomfortable teaching AI (Chiu et al., 2023). Therefore, studies will be conducted in Morocco to examine the perception of teachers in K-12 classrooms regarding AI integration into the curriculum. The negative attitude of teachers toward AI education may also affect their willingness to teach with AI as a learning resource (Qin et al., 2020).

Another critical hindrance is teachers' limited understanding of AI, resulting in insufficient self-efficacy in making proper use of AI technologies (Wang et al., 2020). AI literacy among educators requires a powerful training framework, which may be difficult to achieve in the short term in Morocco. UNSECO/IFIP's 2019 report emphasizes that the majority of countries lack the resources or time to provide comprehension training for teachers in CS (Storte et al., 2018). Furthermore, the attraction of higher salaries in AI-related fields often draws graduates away from teaching, exacerbating the shortage of AI teachers. To resolve the issue, the government should offer competitive salaries and additional rewards to AI graduates entering the education field. Moreover, retraining current teachers presents challenges such as resistance to adopting AI methods and the costs associated with retraining. Further research is needed to explore the processes of training teachers on this topic and incorporating it into the educational system (Chiu et al., 2023).

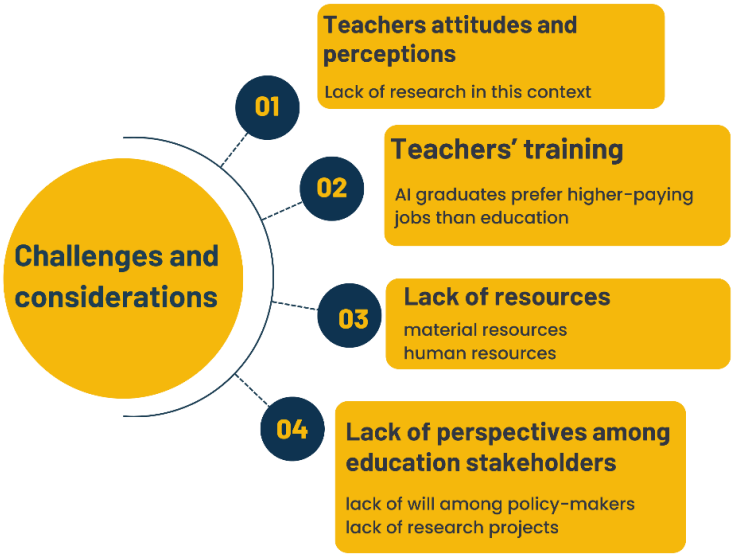
Another important barrier is the inadequate human and material resources in educational settings. This challenge is particularly critical in developed countries, where integrating AI into education is hindered by issues like resource scarcity, poor infrastructure, limited internet access, and power supply problems (Mogaji & Jain, 2020) (Kumar et al., 2023). In Moroccan schools, computer facilities are often insufficient or nonexistent. As a result, existing CS program units are often neglected or only partially covered, compromising the achievement of desired educational outcomes. This issue becomes even more complex when considering the addition of AI units or modules.

Additionally, there is limited involvement of policymakers and researchers in the field of AI in education in Morocco, creating a significant deficit in terms of understanding and practice.

This deficiency is evident in the lack of research papers dedicated to AI in education. Policymakers may find it difficult to design or implement policies if they lack structures or frameworks that are suitable for modern learning environments. Thus, this gap requires interdisciplinary cooperation between AI specialists, teachers, and policymakers. This collaboration will lead to not only discussions but also evidence-based solutions for effective frameworks to incorporate AI into education. The challenges described here are summarized in Figure 3.

Figure 3.

Summary of challenges related to AI integration in Morocco



Recommendations and call to action

Choosing a strategy to incorporate AI into the CS curriculum is a complex task, as it depends on many factors, including financial conditions, infrastructure, and human resources. Based on the proposed pathways and the discussed challenges within the Moroccan educational context, we suggest a three-step integration process by implementing the approaches in succession, from the easiest to the most difficult. Therefore, we propose starting in the first few years with *Approach 2*, which involves introducing AI concepts into existing modules. This approach does not require a complete reform of the CS program, which may take years to update. Subsequently, we can move on to *Approach 1*, in which a well-adapted AI module is added to the CS program. This could result in a reduction of time allocated to certain existing modules, the omission of one or more modules, or an increase in the hourly volume of the CS program, which may require hiring more teachers and equipping them with better resources. Finally, *Approach 3*, the most costly option, would involve large investments in teacher training, developing school infrastructure, and adjusting other programs to accommodate the CS program in the second and third years of high school.

Policymakers may choose to follow this proposed strategy or implement only one or two approaches based on financial conditions and policy priorities. This study provides general

pathways for AI integration but does not offer detailed guidelines. Achieving clear guidelines requires studying each approach in more depth, considering current and future circumstances, as well as political, societal, and economic factors. To this end, more research and effort are needed, involving academics, policymakers, and other stakeholders.

CONCLUSION

The importance of scientific reasoning in present societies cannot be overlooked, and this calls for the integration of this concept into early learning (OCDE, 2015). AI education is among the best ways to nurture scientific reasoning and computational thinking. At present, it is crucial to include AI courses in pre-university education, with high school being the best stage for this, as students at this level are more prepared to learn complex material (Estevez et al., 2019). Therefore, if AI is well integrated into the standard CS curriculum and linked to other units such as programming and algorithms, students will gain a general understanding of the role of AI in computing. This integration will also ensure that students are equipped to use AI technologies effectively and understand their ethical and societal impacts. In the Moroccan context, several challenges, such as curriculum overload, teacher training, and resource deficiency, may hinder the process of AI integration into CS courses. These issues must be addressed to ensure an effective AI integration and provide a curriculum that includes both CS and AI concepts (Iqdour et al., 2021). To achieve this goal, policymakers, educators, researchers, and all stakeholders must be involved in the formulation, development, and assessment of a new CS curriculum that includes AI.

This study offers reflections on why and how AI education should be incorporated into the high-school CS curriculum in Morocco, as no prior research has been conducted on this topic. This study could provide valuable background knowledge and be helpful for further research, educational institutions, and government organizations to understand the current state of pre-tertiary AI education. Future research will focus on developing an AI education framework tailored to the Moroccan educational context and the needs of young learners. This research will include the development and evaluation of AI workshops for high-school students to provide hands-on experience in real-world conditions.

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