AI platform model on 4IR megatrend challenges: complex thinking by active and transformational learning

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Abstract

Purpose – The objective of this study is to propose a model for the implementation of a technological platform for participants to develop solutions to problems related to the Fourth Industrial Revolution (4IR) megatrends, and taking advantage of artificial intelligence (AI) to develop their complex thinking through co-creation work.

Design/methodology/approach – The development of the model is based on a combination of participatory action research and user-centered design (UCD) methodologies, seeking to ensure that the platform is user-oriented and based on the experiences of the authors. The model itself is structured around the active and transformational learning (ATL) framework.

Findings – This study highlights the importance of addressing 4IR megatrends in education to prepare students for a technology-driven world. The proposed model, based on ATL and supported by AI, integrates essential competencies for tackling challenges and generating innovative solutions. The integration of AI into the platform fosters personalized learning, collaboration and reflection and enhances creativity by offering new insights and tools, whereas UCD ensures alignment with user needs and expectations.

Originality/value – This research presents an innovative educational model that combines ATL with AI to foster complex thinking and co-creation of solutions to problems related to 4IR megatrends. Integrating ATL ensures engagement with real-world problems and critical thinking while AI provides personalized content, tutoring, data analysis and creative support. The collaborative platform encourages diverse perspectives and collective intelligence, benefiting other researchers to better conceive learner-centered platforms promoting 21st-century skills and co-creation.

Keywords AI-assisted educative platform, Megatrends and education, Educational innovation, Higher education, Education 4.0, Complex thinking, Fourth industrial revolution

Paper type Research paper

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Introduction

The megatrends of the 4th Industrial Revolution (4IR) are far-reaching, high-impact tipping points that are shaping the way we live, work and interact in society. The 4IR represents an unprecedented change in the way we interact with technology and address global challenges (Schwab, 2017). 4IR megatrends are driven primarily by technological advances and innovations in various sectors of the economy and everyday life. From furthering sharing economy models to the digitization of matter, they are also interrelated and mutually reinforcing, resulting in a profound transformation of society. Given their sociotechnical implications, megatrends pose not only opportunities but all the more significant risks.

While bringing with it many strides and advantages, 4IR megatrends also present challenges and issues that must be addressed to maximize their benefits and minimize potential negative impacts. Some of the issues entailed by these megatrends include environmental impact of the growing demand for technology and the generation of e-waste, non-equitable access to technology resulting on a wider economic and digital divide, automation and robotization leading to the elimination of certain jobs and the need for new skills and access to large amounts of information online causing the spread of fake news, disinformation and misinformation. To counteract citizens' shortfall in knowledge and skills with respect to the rapid evolution of technology, it is imperative to leverage educational strategies and continuous training that will equip people to meet emerging and future challenges.

A state-of-the-art overview on the importance of developing individuals' complex thinking foreshadows its potential impact on education and training. According to Morin (1992), complex thinking is a means of understanding interconnected ideas by examining their individual parts, however contradictory they may seem, and recognizing how they influence each other in a continuous feedback loop. Envisioned as a macrocompetency, following Ramírez-Montoya *et al.* (2022), complex thinking integrates innovative, critical, scientific and systemic thinking, preparing learners to address the intellectual challenges of this century. Regarding the higher education arena, a study by Farias-Gaytan *et al.* (2023) on digital transformation in the face of complexity emphasized the need to improve the digital literacy of educators and students to deal with the demands of the workplace and suggests institutions assess and strengthen their competencies to optimize learning outcomes. In an analysis of the role of researchers in facing the challenges of the converging open science and open innovation paradigm, Sanabria-Z *et al.* (2023a) highlighted the lack of awareness of the concept of complex thinking and how crucial it will be in the training of future managerial professionals. As we move forward with Education 4.0, featuring technologies such as artificial intelligence (AI), the Internet of Things (IoT) and blockchain, tapping into their potential to foster and assess complex thinking in educational scenarios becomes critical.

The emergence of the Education 4.0 school of thought in the context of 4IR prompts to rethink digitally enhanced pedagogical approaches. According to Demartini and Benussi, (2017), Education 4.0 is an emerging profile influenced by Web 4.0 developments, characterized by a deeper human–machine interaction that emphasizes adaptive learning processes, AI-driven educational strategies and a shift toward autonomous learners supported by AI and other technologies; however, according to this vision, the challenges to be faced in the context of Education 4.0 include the constant lagging behind with the rapid technological evolution, the unconnectedness of education with the demands of Industry 4.0, the need for student-centered learning, the insufficient integration of digital technology in education and the lack of exigency for 21st-century skills development. In fact, a transformative change is being witnessed in the education sector with the integration of AI tools and applications such as personalized learning algorithms, intelligent tutoring systems, large language models to support deeper learning, predictive analytics for student performance, automated content creation, virtual reality

simulations and chatbots for student support, heading toward a more successful personalized and immersive learning experience. Thus, although the challenges posed by Education 4.0 are evident, the booming availability of AI tools opens up opportunities to timely respond by implementing educational approaches.

Research on AI applied to learning processes has been growing in recent years, and the impact of AI in education has become more significant. Paek and Kim (2021) have pointed out that research in this field should deepen and diversify, promoting the application of AI algorithms and technologies in education to innovate new ways of teaching and explore its potential in educational environments. In this context, AI applications in education have been identified, from the application in particular processes, such as in mentoring (Kroll and Burova-Keßler, 2022) the adaptation of an entire pedagogical system (Guan *et al.*, 2020), achievement of the historical goals of education, i.e. to be effective, outcome-based, individualized, transformative, interdisciplinary and promote learning for life (Rathore and Dangi, 2021), to the assessment of complex thinking traits through an AI-powered platform (Sanabria-Z *et al.*, 2023b). To contribute to the efforts to innovate in the educational processes to face the challenges of today's society, the proposed design model for the educational platform developed by the authors has been drawn.

In this study, we address the need to adopt more active AI-based approaches to the learning process to cultivate essential 21st-century skills. Therefore, *we propose a model for the design of a learner-centered educational platform supported by AI tools* that will aim to enable students to identify and analyze issues related to 4IR megatrends and arrive at solutions through co-creation. The methodology used to guide the ideation of the model combines participatory action research (PAR), a collaborative approach applied to draw on the expertise of the authors to understand, analyze and enact change in specific contexts (O'Siochru *et al.*, 2020), and the user-centered design (UCD) method, which involves the identification and in-depth understanding of users' needs, wants and expectations based on a series of guiding questions for proposed problem-solving (Jonassen, 2010, pp. 285–305). The structuring of the model was based on two frameworks: active and transformative learning (ATL) (Lytras, 2023), as a primary approach focused on sustainable personal development that seeks to leverage emerging technologies to enhance learning experiences, and 21st-century learning (Trilling and Fadel, 2012), as a secondary approach that presents an adaptive and collaborative lens for integrating essential skills, knowledge and attitudes against the complexities of a tech-driven future. Accordingly, we present the development phases of an ATL-based, AI-supported model development aligned with user needs, aimed at solving problems of the 4IR megatrends, which incorporates iterative feedback to participants during their creative process.

Theoretical framework

Fourth Industrial Revolution megatrends and education

The 4IR, also known as Industry 4.0, refers to the integration of advanced digital technologies into manufacturing and production processes. Some of these technologies include AI, IoT, robotics, augmented reality and virtual reality. Technological advancements have a significant impact on various sectors of society, including education, though the relationship between the 4IR and education is rather complex and multifaceted. The 4IR has driven the demand for 21st-century skills such as critical thinking, problem-solving, creativity, collaboration and digital literacy (Rahman *et al.*, 2020). Educational institutions have recognized the importance of equipping students with these skills so that they can adapt and thrive in the changing workforce.

The 4IR technologies enable personalized learning; with AI systems and data analytics, information about student performance and preferences can be collected, allowing educators to tailor instruction to the individual needs of each learner (Elnaggar and Arelhi, 2021; Jokhan *et al.*, 2022), helping to improve the effectiveness of learning and ensuring optimal progress for each student. Online learning, open educational resources (OER) and digital platforms have expanded learning opportunities, especially for those who do not have access to traditional educational institutions and have facilitated the inclusion of students from diverse backgrounds (Liu *et al.*, 2020; Kumi-Yeboah *et al.*, 2020). This has democratized access to education and enabled people to acquire knowledge and skills regardless of their geographic location or economic situation.

A change in pedagogical approaches has also been brought about by the 4IR. Educators are increasingly incorporating technology into the classroom to enhance student engagement, foster collaboration and provide more immersive learning experiences (Al-Labadi and Sant, 2021). Augmented reality and virtual reality, for example, can transport students to digitally enhanced environments that allow them to explore concepts in a more interactive and hands-on way, enabling a more significant impact on improving students' learning capacity (Babini *et al.*, 2020). Furthermore, the demand for technical skills is increasing in the education industry, where professionals capable of leveraging emerging technologies to enhance educational processes, experts in educational technology and digital curriculum design and specialists in educational data analytics are widely sought after. Addressing the 4IR megatrends requires the design of educational experiences that prepare learners to adapt to a rapidly changing technological landscape.

Complex thinking and co-creation through active and transformative learning

Complex thinking can help people collaborate to create new and innovative solutions by combining different ideas and perspectives. Integrating complex thinking into the co-creation process represents a significant factor involving a collaborative and participatory approach where individuals with diverse backgrounds, expertise and skills jointly create something new, be it a product, service or solution (Pee, 2019). It entails understanding and navigating intricate systems, connections and relationships, which is highly relevant in co-creation (Turner and Baker, 2019). This ability allows participants to appreciate and respect diverse perspectives and insights (Saha *et al.*, 2021). By recognizing the value of multiple viewpoints, complex thinking enables co-creators to leverage collective wisdom and tap into a broader range of ideas, enhancing the group's creative potential (Astola *et al.*, 2021) and understanding the larger context of the creation process. By engaging in complex thinking to embrace a range of viewpoints and understand complicated systems, people may work better together, moving smoothly to the next steps of co-creating lasting intelligent solutions.

Co-creation is often an iterative and adaptive process, with continuous refinement based on feedback and learning. Engaging in collaborative projects encourages learners to explore unconventional solutions and think beyond established norms, which fosters creative and innovative thinking, essential components of complex thinking (Ghahremani *et al.*, 2021). Complex thinking, and in particular systems thinking, helps co-creators analyze and understand interdependencies, feedback loops and system dynamics (Wynn and Maier, 2022); it helps them recognize nuances, interplay and interdependencies between different elements, enabling innovative solutions that reconcile diverse viewpoints and optimize outcomes. Effective collaboration and tapping into collective intelligence are essential for successful co-creation (Groth *et al.*, 2020). In the exploration of complex thinking and co-creation, the need for educational approaches that adapt to our rapidly evolving technological world keeps rising.

Today's educational challenges require pedagogical frameworks to help prepare students to navigate and shape a technology-driven future. As such, active learning is a learner-centered approach that involves engaging methods to face real complex challenges (Chen and Liu, 2020). It fosters analysis and evaluation, to critically process information for validity and reliability (Styers *et al.*, 2018), involves collaborative activities to understanding complex topics (Membrillo-Hernández *et al.*, 2019), emphasizes metacognition, and self-reflection (Chan *et al.*, 2021) and enables students to address complex problems more effectively. Yet, the rapidly evolving workplace demands constantly updated educational strategies to better prepare students to navigate and innovate in our fast-changing world.

Although active learning as such offers a solid foundation, it is pertinent to explore current educational approaches that might yield greater versatility and scope. Stepping further, a recent framework for learning in higher education, which at once provides a holistic educational paradigm, is ATL, aimed at enabling meaningful learning experiences for students with an emphasis on the integration of digital advances (Lytras, 2023, June). ATL presents seven pillars of interest, namely, knowledge and content, learning strategies, technology enhanced learning enhancement, skills and competencies uniqueness, faculty capacity to implement, administrative support and educational leadership and impact measurement and learning analytics; as a whole, ATL is oriented toward the integration of foundational principles and innovative technologies to sculpt future educational paradigms in higher education amid the ongoing digital transformation (Lytras, 2023). In light of the 4IR megatrends and Education 4.0 technologies, it is pertinent to consider how the pillars of ATL can be strategically leveraged to equip learners with essential competencies, fostering a systematic and critical approach to innovatively solve complex real-world problems.

Artificial intelligence as a driver to boost creativity for solving megatrend challenges

Traditionally, creativity has been associated with human imagination and intuition, but AI algorithms can analyze vast amounts of data to generate new ideas and concepts based on patterns, trends and correlations that can aid enhancing creativity. AI-powered idea generation tools can suggest new combinations or variations to spark fresh perspectives to current challenges (Skulimowski and Köhler, 2023). Furthermore, AI can foster co-creation and collaboration among individuals by offering platforms and tools for remote collaboration, idea sharing and feedback (Porter and Grippa, 2020). Using sophisticated algorithms, AI can analyze input from multiple participants, identify common themes and help integrate diverse perspectives, enabling a collective and collaborative creative process (McCormack *et al.*, 2020). AI's capabilities, such as natural language processing and image recognition, allow it to analyze and understand vast amounts of content, assisting in content creation by suggesting relevant keywords, optimizing content for specific audiences or generating personalized recommendations (Hwang *et al.*, 2020). The versatility of AI to automate recurring creative tasks such as editing increases productivity by freeing up cognitive resources for creators to focus on more advanced decisions.

The combination of human creativity and AI's capabilities can lead to innovative and compelling creative outcomes. In addressing complex problems related to 4IR megatrends, creative minds are faced with analyzing large databases in which patterns and trends must be identified, an opportunity to leverage AI as an indispensable tool for accelerating processes, enhancing human potential. AI algorithms can effectively personalize creative experiences by tailoring content or recommendations to individual preferences and interests, delivering more relevant insights and experiences (Verganti *et al.*, 2020). Still, although AI can augment the creative process, the final creative decisions and expressions remain rooted in human imagination, intuition and judgment, where the tool seeks to augment rather than

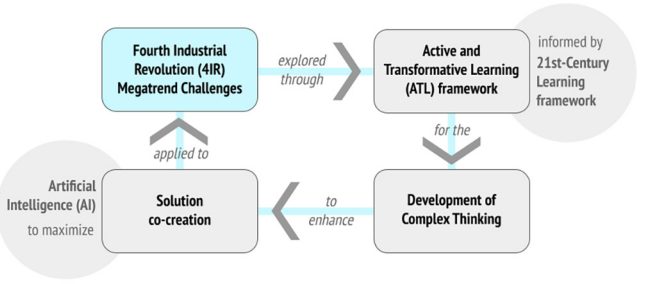
replace human creativity (Anantrasirichai and Bull, 2020). Ultimately, AI can serve as a powerful ally in the innovation process, amplifying human creativity to address the manifold challenges posed by the 4IR megatrends, providing data-driven intelligence and accelerating repetitive tasks while respecting the irreplaceable value of human intuition and imagination toward the final formulation of ideas and expressions. An overview of the above theoretical framework is shown in Figure 1.

Research methodology

To guide the design of an AI-supported platform model that allows students to propose solutions to the challenges of 4IR megatrends, we used a combination of the PAR approach with the UCD methodology. Such a learning environment seeks to respond to the objective of fostering creativity, innovation and the exchange of ideas and knowledge to promote the development of 21st-century life skills and competencies. To configure the platform, considering the development of student competencies, the ATL and 21st-century learning frameworks were taken into account. This blend of approaches and frameworks allowed the development of an evidence-based platform that meets user needs.

The PAR is a research approach that seeks to promote changes and improvements in specific situations or contexts through active collaboration between researchers with expertise in the field and participants (Bradbury, 2015, pp. 1–9); it implies a common understanding of the problem, observation, collaborative analysis and action planning and implementation and also prioritizes the value of experiential knowledge to address the object of study or a given problem, to generate conclusions and strategies that promote change (Lenette, 2022). In the present proposal, we, the authors, have expertise in the field of educational innovation and communication processes in formal and nonformal education. To determine the direction of the model, we participated in remote sessions using a logbook as an instrument to collect data by registering their insights and co-creative proposals, which gradually evolved into a scientific article. As participants in this study, we envisioned that the development of young people in higher education would be enriched by the development of capacities and skills around the megatrends of the 4IR. To this end, we considered that an educational platform such as an OER supported by AI tools, could be an appropriate tool to invite young people to recognize and analyze the megatrends and their challenges, as well as to motivate the work of co-creation in the search for solutions.

The UCD is an approach that places users at the center of the design process (Istance and Kools, 2013; Cha and Ahn, 2019). Based on a set of questions, we engaged in dialogue and



Source: Figure by authors

Figure 1. Theoretical framework flow to address 4IR megatrend challenges

reflection to define the role and scope of the proposed model, taking into account the potential users' role. The questions that guided the design of the platform model were: How will the platform be used, who will use it and for what purpose? Who will the users be? What information will the users need? What prior knowledge are the users expected to have? How will a user interact with the proposed platform? UCD also involves recognizing and envisioning the user's learning experience as the user goes through the pedagogical strategies leading to the stated objective (Franco *et al.*, 2020).

The ATL framework (Lytras, 2023) was integrated considering it seeks to address the need for higher education and institutions to equip individuals with advanced skills and competencies to meet new global challenges and transitions. Given that ATL encompasses seven pillars, only the most relevant to the model will be addressed during the process. To inform those pillars, the 21st-century learning framework (Trilling and Fadel, 2012, p. xxvi) is considered, which aims to support in reinventing education, emphasizing the development of core skills such as critical thinking, problem-solving, digital literacy and creativity, providing guidance for adapting education to the changing demands of our time.

The focus in the design of the model is on creating a dynamic and interactive teaching environment to foster student engagement and motivation (Do Amaral, 2023), actively involving students in their own learning process, encouraging their active participation, critical reflection and practical application of knowledge in real contexts. To design context-sensitive and learner-centered educational environments, the steps followed by the authors to arrive at the design of the proposed model are shown in Figure 2.

This combination of approaches and frameworks ensures that the educational AI-powered platform model is aligned with user needs and expectations, effective in facilitating the co-creation of megatrend solutions, while supported by a strong research and development base. As part of their working approach, the authors used the AI tool ChatGPT, a language generation tool that creates human-like text from given inputs (Brown *et al.*, 2020), configuring it as a "possibility engine" in accordance with the guidelines provided in the document "ChatGPT and AI in higher education" (UNESCO, 2023). This guidance suggests that AI can be used as a means to generate various alternative ways of articulating an idea. This does not represent considering it as a third author, but rather that its use is limited to being a tool to obtain alternative ways to express an idea; each of these alternative outputs was analyzed by the authors to be either considered or discarded. The research and design work represented a collaborative and equitable activity, from the process of collecting and analyzing the bibliography, the approach to the pedagogical approach and the design of the model itself, for which specific spaces and times were established throughout the process to discuss and configure the model.

Results

Designing an AI platform educational model for co-creation of solutions on 4IR megatrends requires careful consideration of both the educational and co-creation aspects. The results section toward the development of the model is based on the authors' discussion outcomes regarding the five stages presented in Figure 2. To address educational aspects, it is essential to first identify the educational objectives. Then, we can define the desirable deliverables of the process of co-creating solutions within the framework of the 4IR megatrends.

The first stage focused on the identification of objectives. In the platform we propose here, the main objective agreed was for students to improve their learning and develop complex thinking based on the recognition and resolution of problems related to 4IR megatrends. Specific objectives were stated as identify potential target user needs to address

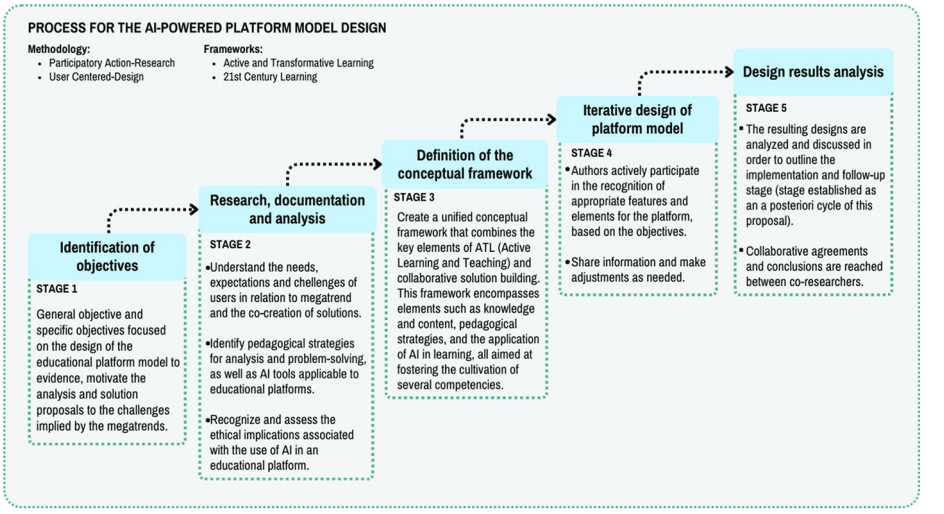


Figure 2.
Process followed for the AI-powered platform model design

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the main objective; recognize frameworks that can inform the model taking ATL pillars as the main focus; and determine platform features to achieve the main objective.

A second stage, research, documentation and analysis, focused on understanding potential user needs, identifying strategies and identifying ethical implications. Given the complexity of global challenges related to 4IR megatrends, young people require the development of certain competencies to effectively address them. As for higher education students, they require those that facilitate critical introspection regarding their actions, taking into account social, cultural, economic and environmental impacts from both local and global perspectives (OECD, 2020). Meeting these needs is crucial for preparing students to face challenges and leverage opportunities in their academic journey and future careers. Engaging them in recognizing and analyzing 4IR megatrends could enable the development of a deep understanding, analytical and foresight skills, adaptability, ethical awareness and innovative problem-solving.

In addition to recognizing user needs from the process of analysis and documentation, we identified applications of AI in educational aspects that could be useful in the platform model. Some of the relevant functions provided by AI tools are described below:

- Personalizing learning through the use of AI algorithms enables the analysis of each student's progress and preferences. This, in turn, allows for customizing educational content and activities to meet individual needs, thereby enhancing student comprehension and engagement (Xie *et al.*, 2019; Alamri *et al.*, 2020a, 2020b; Lin *et al.*, 2019). Adaptive educational systems have great value in advancing individualized education. These systems generate precise profiles and models of students based on factors such as their knowledge levels, personality traits and skills. By accounting for these variables, accurate results are achieved. The AI-based Student Assessment and Recommendation System provides customized recommendations to enhance student learning (Bagunaid *et al.*, 2022).
- Tutoring and feedback are essential components of modern education. Chatbots and virtual assistants can provide personalized tutoring and real-time feedback to

students. These AI assistants can answer questions, provide explanations and help students solve problems (Yüce *et al.*, 2019; Kochmar *et al.*, 2020); intelligent tutoring systems can also serve this function (Anwar *et al.*, 2022b). AI-powered tools, like the Meeting Mediator, provide swift feedback on group dynamics and individual behavior, delivering instant suggestions to participants and promoting effective collaboration and sustained advancement in both commercial and remote learning contexts (Kroll and Burova-Keßler, 2022).

- Data analytics and prediction enable educators to intervene promptly to provide additional support to students in need and offer insights into student interactions and performance (Khan and Ghosh, 2020; Kamruzzaman *et al.*, 2023). Some examples of these tools are found in Learning Analytics Platforms, such as Blackboard Analytics, Moodle Learning Analytics and Canvas Analytics. They generate learning analytics reports that allow educators to track student performance and progress (Baker, 2023), and Early Warning Systems such as Starfish or Early Alert, both of which are tools that issue alerts to identify students at academic risk and provide timely support (Arafiyah *et al.*, 2021).
- AI tools can provide resources and content through recommendation systems to ensure that learners have relevant materials and additional resources that could leverage their learning experience. Educational platforms like Coursera or edX showcase the effectiveness of this algorithm by offering personalized recommendations and suggestions that can be increased with the advanced capabilities of adaptive learning AI tools (Kulkarni *et al.*, 2020; Kabudi *et al.*, 2021).

To fulfill this stage, we acknowledge the ethical implications of using AI tools on the platform. To ensure student data is safeguarded, appropriate informed consent must be obtained before collecting personal information. In addition, it is vital to have security systems in place that protect both data and the platform's integrity. Efforts must be made to identify and address any bias that the algorithms used may contain. Thus, a balance between AI automation and the development of crucial human skills, such as critical thinking and learner autonomy, is necessary. It is vital to constantly evaluate whether ethical and educational standards are being followed to make adjustments if required (Han *et al.*, 2023; Huriye, 2023). These aspects should be considered, but it is advisable to be aware of other ethical standards that may be relevant.

In Stage 3, definition of the conceptual framework, we selected relevant strategic pillars of ATL, according to Lytras (2023), to co-create solutions for implicit 4IR megatrend challenges. They were considered as transversal elements that are woven throughout the proposed model and provide it with conceptual support. Of the seven strategic pillars ATL features, four were selected as most directly related to the students' creative process, namely, knowledge and content, ATL to innovatively disseminate knowledge ensuring learning development; learning strategies, ATL as an integrator of knowledge from various sectors, ensuring a global approach to learning objectives; technology enhanced learning enhancement, ATL to leverage emerging technologies and as a fundamental principle driving tech-enhanced active learning initiatives; and skills and competencies uniqueness, ATL to raise and maintain skills and competencies, ensuring that learners acquire resilient and enduring proficiency.

The 21st-century learning framework (Trilling and Fadel, 2012, p. xxvi) was used to inform ATL pillars. To this end, three learning outcomes (skills) entailed by the framework were considered: skills related to learning and innovation, including critical thinking, problem-solving, communication, collaboration, creativity and innovation;

digital literacy skills, covering information literacy, media literacy and information and communication technology skills; and vocational/life skills, including adaptability, flexibility, initiative, self-direction, social and intercultural interaction, productivity, accountability, leadership and responsibility.

As a result of the learning experience provided by the educational platform, young people are expected to develop the macrocompetency of complex thinking. Therefore, basic content was established to stimulate the learning and reflection process around the megatrends. The elements considered were definition and features of the 4IR, i.e. identification of the main megatrends (including AI, IoT, automation, robotics and biotechnology); the impact of 4IR megatrends on the economy and society, by examining how these trends are reshaping various industries and aspects of everyday life, and evaluating the advantages and difficulties stemming from these; and global challenges linked to the 4IR megatrends, identifying global issues such as climate change, social inequality, cybersecurity, data protection, sustainability and health care.

Stage 4 addresses the iterative design of the platform model. Once the educational and content-related aspects were identified, we considered AI-enhanced learning strategies that could improve the learning process, promote critical, systemic and creative thinking, fostering a learning space of co-creation. The research and design process was guided by the UCD approach while ATL pillars 2 and 3 were considered. Pillar 2 recognizes ATL as a learning strategy for achieving multidimensional learning impact, and pillar 3 identifies ATL as a principle for technology-enhanced learning initiatives. Assisted ideation will incorporate AI to endorse idea generation and brainstorming, by providing cutting-edge recommendations and connections to participants to help them explore new possibilities and spark creativity. AI-driven tools are needed to analyze user input, detect patterns and suggest innovative ideas or connections.

As the platform is intended to be a collaborative space, it will be designed to encourage teamwork and knowledge sharing between participants. The model proposed enables the involvement of diverse stakeholders, including researchers, students and practitioners, to provide exceptional viewpoints and insights. As an open model that allows the synergy among several layers of participants, it will include features such as discussion forums, project workspaces and real-time communication tools that enable effective connection, exchange of ideas and collaboration. The platform will enable iteration and co-creation, incorporating features that foster the joint development of ideas and offer tools for feedback and ongoing enhancement of proposed solutions. This can be achieved through real-time coediting tools and recommender systems, which boost efficiency in identifying pertinent information for co-creation. The design of the platform aims to be inclusive and accessible to people with different backgrounds and expertise levels.

Finally, in Stage 5, Design results analysis, mechanisms for future validation and evaluation of the AI-powered platform model proposal are set, such as incorporating peer review processes and voting systems. To enhance the impact of platform participation, it is advised to offer opportunities for implementing and scaling jointly created solutions, such as partnerships with organizations or funding agencies. This section rounds off the five-step process in which the authors agree on the scope of the procedural design conducted to create the model, the key considerations of which are summarized in Figure 3.

Discussion and conclusions

In this research, we have proposed a model for the design of a student-centered educational platform supported by AI tools, from which to identify and analyze 4IR megatrend challenges, to arrive at co-created solutions. This, as an educational exercise that allows the development of complex thinking. Several findings from the research process are presented below:

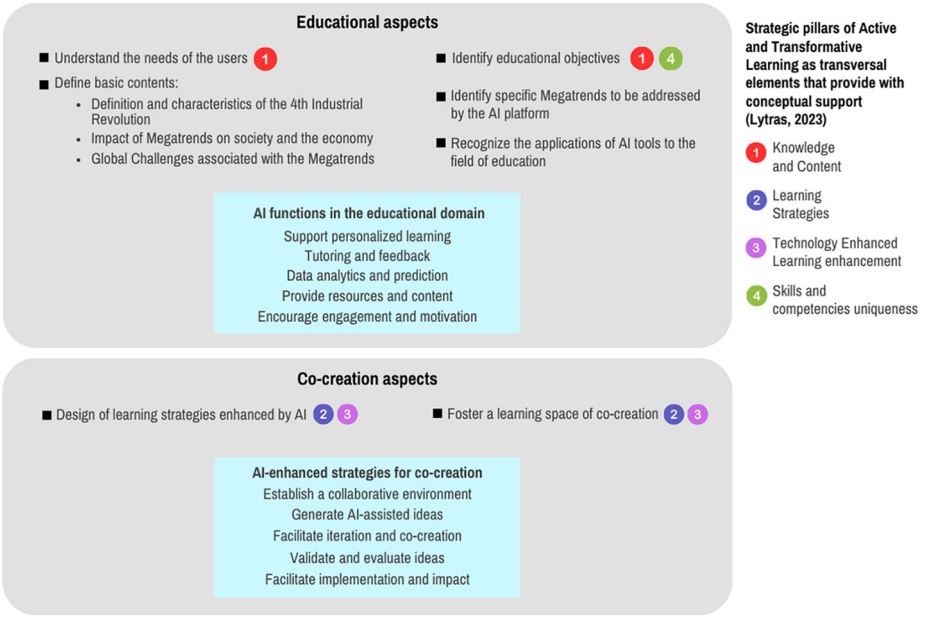

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Figure 3.
AI platform model to co-create solutions on 4IR megatrend challenges

- Combining PAR and UCD to develop educational platforms can help to meet user needs with solid research support. As presented in Figure 2, the methodological process carried out by the authors to design the AI-powered model consisted of five stages that could be replicated in other contexts. The outcomes coincide with the implications pointed out by Lenette (2022), who states how PAR allows prioritizing the value of experiential knowledge to generate strategies toward transformation. Moreover, the use of UCD is in line with Franco *et al.* (2020), who emphasized the importance of focusing on the potential experience of users during their journey in pedagogical activities. The convergence of methodologies such as PAR and UCD, which allow the active participation of researchers while taking into account the potential perspective of users, is suitable for proposing preliminary educational platform models.
- ATL informed by 21st-century learning framework can help students address 4IR challenges. In Figure 1, it was illustrated how ATL can contribute to the development of competencies to address 4IR megatrend challenges. This is consistent with Lytras' (2023) view, and aligned with the vision of Trilling and Fadel (2012), where ATL contributes to fostering the development of skills and competencies to address new challenges that engage students in real-world problems. The combination of 21st-century competency-based frameworks provides an educational umbrella for defining pedagogical strategies and competency development beyond the challenges of the megatrends.
- AI can aid enhance creativity by providing new tools, data analytics and capabilities. With the proposed platform model for co-creating solutions to the challenges of the 4IR (see Figure 3), it is possible to envision how to incorporate AI

to address current challenges. The model complies with those studies that recognize how IA can be adopted as a tool or collaborative assistant for enhancing creative processes (Anantrasirichai and Bull, 2020; Verganti *et al.*, 2020). Thus, AI can facilitate collaboration and without replacing the creative process of humans, but rather encouraging creative thinking to explore its applications in various educational scenarios.

- Integrating AI and ATL into an educational platform can leverage students to co-create solutions to 4IR megatrends. As shown in Figure 3, which summarizes the proposed model, the implementation of AI represents a toolbox that supports both the pedagogical and co-creation aspects that determine the platform's function, and the ATL pillars represent transversal principles that guide the platform's functionality. Such an integration of AI and ATL could provide an explorable approach to the need to overcome the evolutionary gap between technologies and learning in the context of Education 4.0., as observed by Demartini and Benussi (2017). All in all, AI tools when consciously integrated with competency frameworks can represent a revolution in educational strategies, from offering personalized learning to motivating collaboration, ultimately empowering students to take an active role in their learning.
- Co-creation of solutions to the challenges of the 4IR megatrends potentially enables the development of complex thinking. As shown in the resulting platform model (see Figure 3), the role of certain aspects of the co-creation process, such as the identification and analysis of 4IR megatrends problems, allows for the development of complex thinking. Such a process enables co-creators to understand interconnected systems, navigate uncertainty and approach problems from multiple perspectives, as noted by Saha *et al.* (2021). In this way, collective intelligence can be recognized, essential to the co-creation process, as underlined by Groth *et al.* (2020) and Astola *et al.* (2021). This interplay between the complexity presented by the challenges of the 4IR and the benefit for students to develop complex thinking as a tool to analyze them should lead to an improved awareness of the ability to find better solutions to complex problems, beyond the megatrends.

Following the objective of the study, a model for the creation of a student-centered educational platform supported by AI was proposed. This platform aimed to help students recognize and analyze the megatrends of the 4IR, identify their associated problems, and arrive at solutions through co-creation. The goal is to promote the development of essential 21st-century skills, such as complex thinking and the ability to address emerging challenges. The study identified the importance of addressing the megatrends of the 4IR in education, especially in preparing students for a constantly changing world dominated by technology. A model based on ATL was proposed, integrating the competencies and skills necessary to address the challenges and opportunities posed by these megatrends. The educational platform, supported by AI, provides tools for personalized learning, fostering collaboration and reflection, and generating innovative and sustainable solutions.

The proposed educational platform has significant implications for educational practice as it seeks to improve how students acquire knowledge and skills by encouraging their active participation in the learning process. In addition, it promotes collaboration among students and the co-creation of solutions, contributing to more meaningful and relevant learning experiences. For research, this study presents a novel approach that combines PAR with UCD, ensuring that the resulting platform is effective and supported by a strong research and development foundation.

Although the proposed model shows promise in addressing the megatrends of the 4IR in education, there are some limitations to consider. One concerns the need to implement and evaluate the effectiveness of the platform in real educational settings. In addition, the incorporation of AI poses ethical and privacy challenges that need to be addressed with the construction of regulatory frameworks that ensure the responsible use of the technology. Future studies could focus on the implementation and evaluation of the proposed educational platform in different educational contexts and student populations; this would imply focusing on the methodology and indicators to assess the development of complex thinking in platform users. As a first approach, we can allude to the design of evaluation tools that allow the identification of complex thinking skills (critical thinking, scientific thinking, innovative thinking and systemic thinking) before using the platform and at the end of participation in it; likewise, self-evaluation and co-evaluation tools could be implemented to recognize the perception of the student's own development of skills. These are just a couple of approaches that would have to be developed in depth to determine the evaluation processes. On the contrary, another developmental aspect of the proposed model would be to explore how to integrate new technologies and AI approaches to enhance the learning and co-creation process further. Furthermore, future research could address, more broadly, than outlined here, the ethical and social implications of the use of AI in education and the co-creation of solutions.

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