# TOWARDS EDUCATION 4.0: STRENGTHS, LIMITATIONS, AND PERSPECTIVES OF CURRENT PEDAGOGICAL APPROACHES

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## ABSTRACT
The rapid evolution of Industry 4.0 has highlighted the necessity for an educational transformation to bridge the gap between traditional curricula and the evolving demands of the labour market. Education 4.0 emerges as a paradigm shift, aiming to align learning methodologies with the competencies required for the Fourth Industrial Revolution. In this study, we conduct a systematic literature review using the PRISMA method to analyse various pedagogical approaches, including Blended Learning, Project-Based Learning, Serious Games, Problem-Based Learning, Immersive Learning, Simulation Learning and Learning Factories through the lens of Fisk's principles of Education 4.0. The results show that these methods promote learner autonomy, project-centred learning, as well as spatiotemporal flexibility and the ability to choose tools and resources. However, significant gaps remain, particularly regarding the personalisation of learning pathways, student involvement in curriculum design, and the development of data interpretation skills. Notably, no approach fully adheres to all principles, highlighting systemic limitations such as infrastructural disparities and the evolving role of educators as mentors. These findings highlight the need for a thorough reflection on the evolution of educational systems to precisely identify the pedagogical needs and requirements that should be integrated into a future specification document for the development of an educational model adapted to the challenges of Industry 4.0.

*Keywords: Industry 4.0, Education 4.0, pedagogical approaches, PRISMA method, Fisk's principles*

## 1 INTRODUCTION
In recent years, the rapid advancement of digitisation, information systems, and new production technologies has profoundly transformed industries, leading to the emergence of Industry 4.0. This new industrial revolution is characterised by automation, smart manufacturing, and interconnected systems. As a result, businesses must continually adapt to keep up with fast-moving technologies and ever-increasing customer demands. These transformations have also generated new demands in terms of skills and workforce qualification, deeply impacting labour market structures [1]. The structure of the labour market is shifting rapidly. According to the World Economic Forum (2020), 65% of children entering primary school today will work in jobs that do not yet exist. By 2030, many roles will be automated, and more than half of the skills acquired in higher education will become obsolete within five years. Among those trends are the need for lifelong learning and the continuous adaptation of curricula to meet new job market requirements [2]. In line with this, various studies have emphasised the urgency of transforming education and training systems to align with Industry 4.0 requirements [3]. However, the education system struggles to keep up. While efforts have been made to integrate new technologies and update teaching methodologies, a mismatch persists between the skills acquired through education and those sought by companies. This mismatch limits graduates' employability and highlights the need for a thorough rethinking of educational approaches [4]. In this context, Education 4.0 emerges as a solution to bridge the gap between the skills taught in traditional training programs and those required by the job market. The latter not only demands the development of new skills but also considers the diverse profiles of learners seeking to acquire them. Education 4.0 calls for a reconfiguration of learning programs to meet personalised, flexible, and industry-relevant needs [5]. This article presents a literature review on

existing educational systems, analysing and evaluating them through the lens of Education 4.0. This literature review allows for the assessment of current models, the identification of their limitations, and the highlighting of gaps that need to be addressed to better meet the demands of Industry 4.0. The results of this analysis will help identify specific training and skill requirements, which will serve as the basis for developing a specification document that will outline the directions of our future work. Our objective is to design a flexible and adaptive educational system that supports learners in continuously updating their skills in response to labour market changes.

## 2 CONTEXT – STATE OF THE ART

The evolution of educational systems has closely followed the transformations brought by industrial revolutions, adapting to societal needs and technological advancements. This section provides a chronological perspective on these changes, highlighting how education has evolved from a rigid, instructor-led system to more flexible, learner-centred approaches [2][3].

**Education 1.0: The Era of Mechanised Learning (18th-19th Century)**

Education 1.0 emerged after the First Industrial Revolution, marked by mechanisation and the advent of new technologies that facilitated teaching, such as the paper-making machine, the mechanical press, the pencil, and the typewriter. This period was based on an educational model where the teacher was at the centre of the learning process, with the primary role of transmitting knowledge to students, who had a passive role [7].

**Education 2.0: Standardisation and Mass Learning (19th-20th Century)**

The Second Industrial Revolution, in the early 20th century, transformed education to meet the needs of industrial economies. Education 2.0 aimed to democratise access to knowledge and train a skilled workforce through structured, curriculum-centred educational systems. The teacher's role evolved from an authority figure to a facilitator. Peer assessment emerged, while distance learning, through correspondence courses and radio broadcasting, further expanded access to knowledge [7].

**Education 3.0: Digitalisation and Connected Learning (Late 20th Century-Early 21st Century)**

The Third Industrial Revolution introduced computerisation, automation, and the Internet, which make learning more flexible and interactive. Education 3.0 focuses on self-directed learning and connectivism through digital resources and online platforms (MOOCs, COOCs, SPOCs). These innovations paved the way for Education 4.0 [8].

**Education 4.0: Adaptive Learning (21st Century - Present)**

The Fourth Industrial Revolution, known as Industry 4.0, is transforming industrial processes and the labour market through the integration of technologies such as artificial intelligence, the Internet of Things (IoT), robotics, automation, and big data analytics. These developments generate new demands for the workforce not only technical skills like cybersecurity, systems integration, and data management, but also transversal skills including critical thinking, adaptability, collaboration, and problem-solving. Several studies emphasise the growing mismatch between current qualifications and the evolving needs of industry [3][9]. Furthermore, the Organisation for Economic Co-operation and Development (OECD, 2022) confirms that digital transitions closely tied to Industry 4.0 are reshaping skills across all sectors and require urgent adaptation of training and education systems [10]. This context has led to the emergence of Education 4.0 as a pedagogical response designed to bridge the gap between traditional education and industry needs. In this regard, Mukul and Büyüközkan [11] define Education 4.0 as a modern educational system that meets the needs of the Fourth Industrial Revolution. This education aims to expand the skills of learners or new employees to apply new technologies, helping them develop in line with societal changes [2]. Education 4.0 represents an educational revolution that allows learners to be the architects of their own learning through personalised, flexible, dynamic, and adaptive pathways. According to Fisk [12], Education 4.0 is based on nine fundamental principles: 1) Learning is not limited by time or space ; 2) Education is personalised to meet the needs and abilities of learners ; 3) Learners have the flexibility to choose the tools and resources they wish to use ; 4) Education is project centred ; 5) Practical and experiential experiences, such as internships, mentoring, and collaborative projects, are encouraged ; 6) Data is interpreted to identify patterns and trends ; 7) New assessment methods are introduced, such as testing knowledge through concrete projects ; 8) Students actively participate in the design and revision of educational programs ; 9) Learning becomes increasingly autonomous. The integration of Fisk's principles into this analysis is justified by their alignment with the requirements of Industry 4.0, which aims to meet the demands of the Fourth Industrial Revolution. These principles contribute to the development of modern pedagogical

approaches that strengthen the connection between education and industry requirements. Additionally, they provide a framework for evaluating existing methods and identifying gaps for educational models, as shown in the literature review analysis that follows. The evolution of educational systems, influenced by industrial revolutions, has led to more flexible and learner-centred approaches. Education 4.0, in response to the demands of Industry 4.0, is based on a new educational paradigm that emphasises personalisation, and autonomy. Fisk's principles provide a framework to assess the extent to which current pedagogical approaches align with these new requirements. The following literature review analyses these approaches, highlighting their strengths, limitations, and alignment with Education 4.0.

# 3 LITERATURE REVIEW

The main objective of this study is to identify, analyse, and evaluate different pedagogical approaches considering Fisk's principles. To achieve this, a systematic approach is adopted using the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [13].

## 3.1 Selection of literature

In order to ensure the rigor and transparency of this literature review, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was followed. The literature search was conducted using three major academic databases: Web of Science, Scopus, and ScienceDirect. Multiple search queries were formulated by combining keywords related to pedagogical approaches and Education 4.0. For instance, one of the queries used was: "blended learning" AND "education 4.0". The inclusion criteria focused on publications released between 2010 and 2024, written in English, peer-reviewed, and addressing educational systems. Studies were excluded if they were out of scope, duplicates, or not peer-reviewed. After applying these criteria, 57 articles were selected for analysis. The analysis of 57 articles reveals diverse pedagogical approaches in educational systems, with Blended Learning and Project-Based Learning being predominant. Figure 1 illustrates the detailed distribution of these approaches based on the PRISMA method.

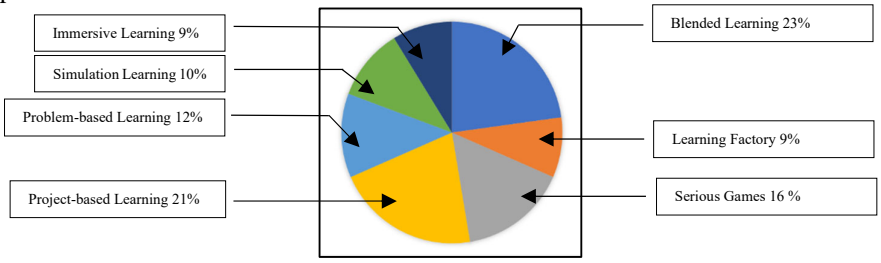


*Figure 1. Distribution of the pedagogical approaches identified in the articles*

## 3.2 Evaluation of pedagogical approaches based on Fisk's principles

The literature highlights various pedagogical approaches that existed before 2010 and have since evolved under the influence of Education 4.0 principles. While these previously mentioned approaches remain relevant, their alignment with Fisk's principles varies. In the first stage, a detailed analysis of Blended Learning and Project-Based Learning (PjBL) was conducted, as these were the approaches for which the most articles were found. This analysis highlights their strengths, weaknesses, and their alignment with Fisk's principles. In the second stage, the same analysis was applied to other pedagogical approaches identified in the literature. A comparative table was created to verify whether each of these approaches aligns with Fisk's principles or not, which will allow for a synthesised view of their integration into Education 4.0. To ensure a structured analysis, the following methodology was applied. The analysis of these selected articles followed these steps: 1) Reading articles to identify elements corresponding to Fisk's principles ; 2) Filling in an Excel table with data on the article's purpose, pedagogical approach, used technology, evaluation method, developed skills, and Fisk's principles ; 3) Synthesising the results by identifying which principles are missing in each approach, as this will be discussed later in the comparative analysis.

Each principle was validated based on the following criteria: 1) Learning is not limited by time or space: Student have flexible access to online resources (MOOCs, e-learning platforms) and availability of learning spaces outside traditional hours; 2) Education is personalised: Learning paths adapted to the student's profile and level, and individualised feedback on progress. For example, Virtual reality allows

students to practice public speaking while receiving personalised feedback on their posture, eye contact, and speech rate; 3) Flexibility of tools and resources: Students have the possibility to choose between different formats (videos, simulations, texts) and access to a variety of learning materials that cater to different learning styles and preferences ; 4) Education is project centred: Use of projects as a learning support, in addition to other pedagogical methods ; 5) Students must engage in practical experiences, including internships, hands-on training, or collaboration with companies ; 6) Data interpretation: Students must analyse information from real and fictional scenarios that allow them to assess and respond to situations dynamically. For example, in medical education, tools like "Vital Sign Simulator" or "iSimulate" generate patient data for students to interpret and make decisions in simulated emergencies ; 7) New assessment methods: Introduction of portfolios, project-based evaluations, interactive quizzes and educational gaming platforms ; 8) Inclusion of students in the development of educational content ; 9) Learning becomes increasingly autonomous: Students seek information and apply their knowledge without constant supervision. They manage their schedules independently.

- **Blended Learning**

Blended Learning combines traditional and online learning through various tools and educational technologies. Hussin [12] draws inspiration from Fisk's trends to adapt teaching methods to modern learners' expectations. In an English course, he applies the flipped classroom model, where students study theoretical concepts outside class hours using digital materials (videos, PDFs), allowing class time to focus on interactive activities. This approach relies on digital tools such as Open Learning, Mentimeter, Padlet, and Kahoot, which allow students to choose the most suitable resources. However, it requires extensive teacher training and a reliable digital infrastructure, which can be a challenge in certain contexts. Saragih et al. [14] indicate that integrating online and in-person elements requires careful planning and synchronisation between digital tools and traditional methods. Furthermore, while Hussin's approach aligns with several principles of Education 4.0, some aspects of Fisk's framework remain partially or entirely unaddressed, such as student involvement in curriculum design, data interpretation to develop analytical thinking, and practical experiences (internships and collaborative projects).

- **Project-Based Learning (PjBL)**

Project-Based Learning (PjBL) is a method in which students develop skills through the resolution of complex problems over an extended period [15]. The studies by Guo et al. [16] and Hosseinzadeh et al. [17] demonstrate its effectiveness in problem-solving, the application of theoretical knowledge, and the improvement of collaborative skills. Crespí et al. [18] highlights its role in the development of transversal skills, such as time management and communication, through student involvement in societal issues. However, its success depends on students' initial skills and the training of teachers. Additionally, its occasional application limits its long-term impact. PjBL aligns with several principles of Education 4.0 defined by Fisk, including project-centred learning, spatiotemporal flexibility, choices of tools and resources, and practical experiences [17]. Moreover, it introduces new assessment methods, such as portfolios and project-based evaluations. However, some limitations persist. Students do not benefit from truly personalised learning, as topics are generally imposed by teachers. The integration of data analysis in the process remains insufficient, limiting the development of analytical skills. Additionally, students do not actively participate in curriculum design.

### 3.3 Comparative analysis

To better understand the alignment of various pedagogical approaches with Fisk's principles of Education 4.0, a comparative analysis was conducted. The results, summarised in Table 1, highlight key alignments and gaps across different methods (An "×" indicates that the principle is applied in the approach). The analysis highlights that none of the approaches fully encourage student involvement in the design and revision of curricula, emphasising the need to integrate them more actively into this process to better tailor learning to their needs and expectations. Additionally, approaches such as Blended Learning, PjBL, PBL, Serious Games, and Learning Factory lack personalisation and data interpretation, which are crucial for addressing individual needs and developing analytical skills. Only Simulation Learning partially integrates data interpretation. Regarding flexibility, PBL, Learning Factory and Simulation Learning are constrained by time and space, whereas Blended Learning, PjBL, Immersive Learning, and Serious Games offer greater freedom. However, the latter do not always allow students to freely choose their tools or resources, unlike Blended learning, PjBL, PBL, Simulation learning and Serious Games. While project-based learning is well integrated into most approaches, it is less present in Serious Games, which focus more on interactivity than on complex problem-solving.

Finally, all approaches align with the principles of innovative assessment methods and increasing learner autonomy.

*Table 1. A comparative analysis of pedagogical approaches*

| Fisk's nine principles | Blended Learning | Project-Based Learning | Problem-Based Learning | Immersive Learning | Simulation Learning | Serious Game | Learning Factory |
|---|---|---|---|---|---|---|---|
| Limited time/space | × | × | | × | | × | |
| Personalisation | | | | × | × | | |
| Choices of tools and resources | × | × | × | | × | × | |
| Project centred | × | × | × | | × | | × |
| Practical experiences | | × | × | × | × | × | × |
| Interpretation of data | | | | | × | | |
| Assessment methods | × | × | × | × | × | × | × |
| Students' participation | | | | | | | |
| Autonomy | × | × | × | × | × | × | × |

### 3.4 Discussions

The comparative analysis reveals that no pedagogical approach fully meets Fisk's nine principles. One significant shortcoming in current pedagogical approaches is the lack of personalisation and the limited involvement of students in the design and revision of educational programs. Personalisation cannot exist without allowing students to take part in shaping the content and structure of their education. Without their contribution, curricula remain rigid and fail to adapt to individual needs, learning styles, and evolving industry demands. Another critical gap concerns the ability of students to interpret data, which is becoming a key skill for the future. As artificial intelligence (AI) plays a growing role in decision-making, understanding and analysing data is essential for making informed choices. For example, AI-driven systems require individuals not only to use automated tools but also to assess the reliability and relevance of the data they produce. Without proper training in data interpretation, students risk becoming passive users rather than active contributors in data-driven environments. Furthermore, the literature review highlights that few pedagogical approaches explicitly focus on developing personal skills such as leadership, emotional intelligence, negotiation, entrepreneurship, and adaptability. While Education 4.0 aims to promote both technical and non-technical skills, most existing training models still prioritise knowledge acquisition and technical expertise at the expense of these essential abilities. Yet, in Industry 4.0, where the work environment is increasingly complex and constantly evolving, these human skills play a key role in employability and professional development. Beyond these elements, there are inherent limitations in Fisk's principles. On one hand, while they emphasise autonomy, adaptive learning, and spatial-temporal flexibility, they fail to consider inequalities in access to digital technologies, particularly in regions with limited infrastructure. By assuming universal access to digital resources, these principles risk exacerbating disparities among learners. On the other hand, by emphasising learner autonomy, Fisk minimises the crucial role of teachers in guiding the learning process. While autonomy is essential, many teachers do not have the necessary training to take on the role of coach or mentor effectively. This transition requires specific skills: knowing how to guide without imposing, providing appropriate feedback, and managing diverse learning profiles.

## 4 CONCLUSIONS

This study analysed seven pedagogical approaches through the lens of Education 4.0 principles, highlighting their strengths and limitations when considered individually. As a continuation of this initial analysis, a future step will focus on exploring the possible relationships between these approaches. The aim will be to identify their common points, differences, and how they might complement one another. This exploration is expected to open the way for combining multiple methods in order to design a training system that is more coherent, adaptable, and aligned with diverse needs. This logic of combination aligns closely with the transformations brought about by Industry 4.0, which are reshaping not only industrial processes but also the skills expected of future professionals. As noted by several authors [19], the rise of automation, data analytics, connected objects, and artificial intelligence is leading to the elimination of many low-skilled jobs, while simultaneously creating new hybrid roles at

the intersection of IT, engineering, and management. In this context, Education 4.0 cannot simply adapt its content; it must also transform its methods, formats, and overall approach to learning. The challenge is to design a modular, personalised, and flexible training system that can adapt to varied learner paths, foster both technical and transversal skills, and support autonomy, lifelong learning, and interdisciplinary collaboration. By proposing an integrated approach based on the complementarities between pedagogical methods, this study provides a structured framework to rethink instructional design in a way that better aligns education with industrial realities. It contributes to turning Education 4.0 into a concrete and operational response to the evolving needs of employability in a rapidly changing technological world.

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