

augMENTOR

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List of acronyms

Acronym	Description
AI	Artificial Intelligence
AIED	Artificial Intelligence in Education
AR	Augmented Reality
augMENTOR	Augmented Intelligence for Pedagogically Sustained Training and Education
ASSURE	Analyze, State objectives, Select materials, Utilize materials, Require learner responses, Evaluate
ATF	Activity Theory Framework
CHAT	Cultural and Historical Activity Theory
EU	European Union
ET	Emerging Technologies
HE	Higher Education
ICT	Information and Communications Technology
ITS	Intelligent Tutoring System
LMS	Learning Management System
ML	Machine-Learning
NLP	Natural Language Processing
PeDeMET	augMENTOR Pedagogical Design Model with Emerging Technologies
PF	Pedagogical Framework
R&D	Research & Development
RRI	Responsible Research and Innovation
SLR	Systematic Literature Review
TEL	Technology Enhanced Learning
TESA	Technology - augmented Educational Scenarios and e-Activities
TPACK	Technological Pedagogical Content Knowledge
VR	Virtual Reality
WoS	Web of Science

Executive summary

This deliverable offers a comprehensive analysis of the first two tasks in WP3, namely T3.1 "Emerging Technologies in Education and Training: A state of the art" and T3.2 "The augMENTOR Pedagogical Framework".

According to the state of the art that we conducted for the first task we identified the absence of a pedagogical framework in existing literature that adequately meets the project's needs. Specifically, it was found that existing pedagogical models or approaches are only partially utilised, necessitating the development of an innovative approach that has not yet been attempted.

For the second task, a literature review led to the proposal of a novel framework focused on the activities of students and teachers when using technological tools, particularly artificial intelligence. This decision stems from the observation that existing models are too general and inadequate for classroom-level lesson design. Therefore, we have built upon well-known models such as ADIE, introducing a new approach that differentiates between the macro level, grounded in theoretical assumptions, and the micro level, focused on classroom implementation. Our proposed framework employs Activity Theory both as an analytical and a design tool, seamlessly integrating technologies into pedagogical design. Consequently, we recommend expanding the traditional teaching triangle to an enriched pedagogical triangle to incorporate all facets of the teaching triangle's knowledge.

Additionally the augMENTOR framework, takes under consideration all the knowledge that teachers should possess when teaching technology, suggesting extension of TPACK- Technological Pedagogical Content Knowledge to TETPACK, for the ET to stand for the Emerging Technologies and specifically AI. At the classroom level, we propose a data-driven model that bridges the gap between theoretical foundations and practical application, the Technology- augmented Educational Scenarios and e- Activities, serving as a bridge between theoretical foundations and practical application. This framework also is the bridge to align users requirements (D2.1), the the proposed Learner Model (T3.3.), WP4 Critical Thinking and Creativity and specifically T4.2 Integration of Creative Pedagogy in the agMENTOR solution, T4.3 Methods and Tools for the assessment of 21st century competencies, WP5 and the augMENTOR solution and specifically T5.1 Data and Educational Resources Mapping, Fusion and Orchestration, and the cross validation of the project (WP6).

1 Introduction

This deliverable proposes a new Pedagogical Design Framework, the **augMENTOR Pedagogical Framework (augMENTOR PF)**, for the augMENTOR project. Based on our analysis of the current state of the art on Emerging Technologies in education (chapter 2), Instructional Design and Learning Design models. Based on the aforementioned we find that these models occasionally emphasise the teacher, the learner, and the content (knowledge), or specific combinations of these elements. However, a singular focus on either the teacher, knowledge, or learner can pose challenges to create an integrated and coherent teaching and learning organisation. In the proposed Pedagogical Design Framework (Komis, 2005; Komis, 2019), the focus is on the overall activity of the class or group of learners, incorporating the learners, the educator, the knowledge to be constructed, and their interactions, as explained in the pedagogical triangle (see next section). This also includes the physical and/or symbolic tools used, in line with Activity Theory (Kaptelinin & Nardi, 2006).

Pedagogical Design, as proposed in this deliverable, is a broader concept than Instructional Design and Learning Design. It encompasses the planning and structuring of educational activities to create meaningful learning experiences and enhance learning outcomes. This involves deliberate choices regarding teaching methods, learning theories, and learner engagement. Additionally, Pedagogical Design integrates various tools and media, with a strong emphasis on Digital Technologies, especially Emerging Technologies. Unlike Instructional and Learning Design, which typically focus on either the teacher or the student, Pedagogical Design considers both the individual participants (educators and learners) and the context of their activities (teaching and learning), the technological and digital tools employed, and the anticipated learning outcomes.

For this reason, the augMENTOR Pedagogical Framework uses human activity, as defined by Activity Theory, as its fundamental unit of analysis. Activity Theory, also known as Cultural and Historical Activity Theory (CHAT), aims to explain human cognition by considering people, their intentions, tools, culture, and inclusive social structures as inherently inseparable components of human activity that collectively constitute thought (DeVane & Squire, 2012).

The augMENTOR Pedagogical Framework expands on the concepts of Instructional Design and Learning Design by adopting a more integrated design model. This model includes the interactions between learners, content (knowledge), and educators, while also significantly incorporating technology into the process. We refer to this as Pedagogical Design with

Digital Technologies. This novel approach aligns with current research in the Learning Sciences, enhancing the **Pedagogical Triangle** through the use of Digital and Emerging Technologies.

The **augMENTOR Pedagogical Framework** consists of two levels, the macro level offers design principles and the micro level operationalizes the classroom activities

- Macro level: augMENTOR Pedagogical Design Model with Emerging Technologies (**PeDeMET**), which contains the general design of pedagogical activity.
- Micro level: Technology-augmented Educational Scenarios and e-Activities (**TESA**), specifies the application of the general principles at the classroom level (in situ e-Activities & online e-Activities).

In this context, the augMENTOR Pedagogical Framework has three (3) distinct objectives (Komis, 2019):

1. To propose a distinct conceptual model, the augMENTOR **Pedagogical Design Model with Emerging Technologies (PeDeMET)**. This model describes the fundamental concepts related to the integration of Emerging Technologies in teaching and learning and proposes the general principles of designing an integrated pedagogical activity (i.e. a structured instruction with clear pedagogical specifications and predefined learning strategies) for teaching a part of the curriculum.
2. Specialise in the design and implementation of this model at the classroom level (defining and applying classroom activities). In this context, the **TESA** approach is **proposed**. **TESA outlines the design of** Educational Scenarios **and** pedagogical e-Activities, **focusing** on the activities of educators and learners using appropriate strategies. These activities aim to achieve specific learning outcomes and utilise an inherently suitable digital environment (based on Emerging Technologies).
3. Examines the implementation of educational scenarios in various educational settings (classroom, blended learning, distance learning) and evaluates the process and its learning outcomes.

Therefore, the augMENTOR Pedagogical Framework places significant emphasis on digital support and enhancement of teaching and learning, concentrating on pedagogical activities facilitated by Emerging Technologies.

The following are described in more detail in the remainder of the deliverable:

- a) The theoretical foundations of the augMENTOR Pedagogical Framework and in particular the enriched Pedagogical Triangle by Emerging Technologies let the global teaching/learning approach, TPACK and T_{ET}PACK, let the design model for trainers and tutors and Activity Theory, as an analytical and prescriptive model for pedagogical activities.
- b) The Macro level: the augMENTOR Pedagogical Design Model with Emerging Technologies (PeDeMET), which contains the general design of the pedagogical activity.
- c) The Micro level: Technology - augmented Educational Scenarios and e-Activities (TESA), specifies the application of the general principles at the classroom level (in situ e-Activities & online e-Activities).
- d) Guidelines for the augMENTOR solution for the anticipated implementation utilising PeDeMET (macro level) and the TESA (micro level).

2 Artificial Intelligence in Education and Training from a pedagogical perspective: A state-of-the-art review

The integration of Emerging Technologies (ET) and more specifically of Artificial Intelligence (AI) in education and training represents a transformative shift in pedagogical practices, offering plenty of opportunities to enhance teaching and learning experiences. There is a growing interest worldwide in understanding how AI and the emerging technologies in general can be leveraged to support and improve education on many levels. Although the initial goal of our work was to investigate the use of emerging technologies in education from a pedagogical point of view, very quickly we were led to the conclusion that since our project specifically concerns AI we should investigate this specific area. The concept of emerging technologies covers a wide range of technologies (Internet of Things, Blockchain, Artificial Intelligence etc..) with diverse characteristics, a fact which means adapted pedagogical frameworks in the majority of cases. This SLR aims to explore the current landscape of AI applications in education and training. Our research focuses on the pedagogical perspective of the use of such tools, in a learning context supported by a learning management system.

As part of the augMENTOR project, another state-of-the-art (SLR) review has been carried out (Deliverable 2.1- Pilots Definition and User Requirements Analysis/2 State-of-the-art: Artificial Intelligence in Education from a technological perspective). This SLR is considered a general state-of-the-art about the use of AI in education, including various aspects of AI applications. The key differences between that SLR and the current SLR are located in their focus and depth. The first review provides a broader overview of AIED, examining the types of algorithms and AI technologies used, the data collected, and the methodological designs employed in AIED research, without a specific emphasis on pedagogy. That broader review covers various technological, methodological, and contextual aspects of AIED, offering a comprehensive state-of-the-art summary. On the other hand, this SLR focuses on pedagogical perspectives, and emphasises how AI enhances teaching and learning practices within learning management systems. It aims to explore the pedagogical frameworks supported by AI, the specific learning outcomes achieved, and to classify AI applications based on techniques and methodologies from a pedagogical perspective.

2.1 Purpose of the study and research questions

The rapid evolution of Artificial Intelligence (AI) introduces opportunities to revolutionise educational practices. To utilise these opportunities, our research aims to conduct a

systematic literature review (SLR) titled "Artificial Intelligence in Education and Training from a Pedagogical Perspective: A State-of-the-Art Review." Concerning the project augMENTOR and its vision to develop a novel pedagogical framework that promotes both basic skills and 21st century competencies by integrating emerging technologies through an open access to an AI-boosted toolkit, our motivation for this review is connected with two (2) primary objectives. Firstly, to investigate if there is literature related to pedagogical models or aspects that are supported by AI techniques and tools. By focusing on creating a novel pedagogical framework, we aim to involve educators, learners, and other stakeholders actively, ensuring that the adoption of emerging technologies is both effective and inclusive. In order to achieve this objective we must first understand what has been done so far in the literature and how our proposed solution (novel pedagogical framework) will include and combine all components such as learners, educators, technological means etc. Secondly, in today's data-driven educational landscape, the development of an AI-boosted learning environment is crucial. A toolkit like this will enable the use of big data and learning analytics to offer personalised learning experiences and resources to learners. This review intends to provide the useful information needed in order to develop this innovative solution, aiming to improve the effectiveness of education and training.

To achieve these objectives, the following research questions were formulated:

RQ1: What are the purposes of using AI in education, and who is the target audience?

This question investigates the motivations behind the integration of AI technologies in education. It tries to explore the specific educational needs that AI technologies are addressing, such as providing personalised pathways, or improving administrative tasks. Additionally, our aim is to detect the target audience of these AI interventions, including learners of different educational levels.

RQ2: Which pedagogical frameworks or pedagogical aspects are supported by AI techniques in education?

This question investigates how AI techniques are integrated into various pedagogical frameworks or pedagogical aspects. It explores how AI is changing the different components of the educational process. By identifying these aspects, our review aims to highlight how AI enhances teaching methodologies.

RQ3: What types of outcomes (cognitive outcomes, soft skills, behavioural outcomes) are introduced in AI-enhanced educational environments?

This question seeks to determine the impact of AI on learner outcomes. It focuses on identifying the specific soft skills, abilities and knowledge that learners acquire in

AI-supported learning environments. Cognitive and non-cognitive outcomes, such as critical thinking skills, problem-solving abilities, subject-specific knowledge, and the development of values like collaboration and ethical reasoning are examined.

RQ4: How can educational AI applications be classified into categories based on techniques and methodologies?

This research question aims to explore the functional classifications of AI techniques and methodologies used. Examining several key categories (Intelligent Tutoring Systems, Learning Analytics and Data Mining, Natural Language Processing etc.), each category leverages specific AI methodologies to address different educational needs, ultimately enhancing the learning experience and outcomes.

2.2 Systematic literature review methodology summary

The section outlines briefly the methodology followed in our SLR (the methodology is described analytically in ANNEX 1). More specifically, the section details the search terms used, the databases accessed, the process flow of identification, the screening, the inclusion of records, and criteria for final selection. Here is an overview:

Methodology: The review followed the PRISMA methodology, with weekly meetings between researchers to discuss selection processes. The SLR focused on studies that presented data on AI's impact on education, using LMS, and AI techniques in online education.

Search strategy: The review started with a comprehensive search strategy, where the key search terms were defined. These search terms included phrases such as "Artificial Intelligence," "Educational Level," "Pedagogical Framework," and "Learning Management System." Boolean operators were used to refine the search across two databases for the period from 2020 to May 2024. The first database was Web of Science (WoS) and the other one was Scopus.

Search reformulation: Initial searches did not return any relevant results, which led to a reformulation of the query to focus on "Purpose Classification" instead of "Pedagogical Framework." This query led to the identification of 225 papers from Scopus and 172 from WoS.

Data management: Duplicates and records with critical missing information were removed, resulting in a final dataset of 295 papers. These papers were screened by title and abstract, and non-English and non-peer-reviewed journal articles were removed.

Inclusion and exclusion criteria: The screening process narrowed the dataset more by excluding records a) not involving human research, b) not utilising AI in the context of online

education, or c) not employing an LMS. This resulted in 199 articles for full-text review, only 38 articles included in the final review.

Final results: The strict screening and selection process ensured a comprehensive and reliable dataset suitable for in-depth analysis, resulting in 38 articles included in the review.

2.3 Systematic literature review findings

In our research, we reviewed thirty-eight (38) peer-reviewed journal articles published between 2020 and May 2024. In order to ensure high quality and relevance of the studies included, we selected journal articles, excluding conference papers and other types of publications like reports and book chapters. Journal articles undergo a thorough peer-review process, which means that they provide reliable findings. On the other hand, conference papers, because of the lack of this process, often present preliminary findings. Book chapters also tend to offer broader, less empirically detailed overviews for the same reason. Additionally, other types of publications like reports and working papers typically lack the peer-review process, which may affect their credibility.

Our review includes two primary databases. The first database is the Web of Science (WoS) with twenty-six (26) articles and the second is Scopus with twelve (12) articles. This approach allows us to present a thorough and reliable analysis of the latest developments in AI applications within educational environments. Figure 1 presents the distribution of selected publications over the last four (4) years. The year 2024 includes papers until the end of May (May 31st).

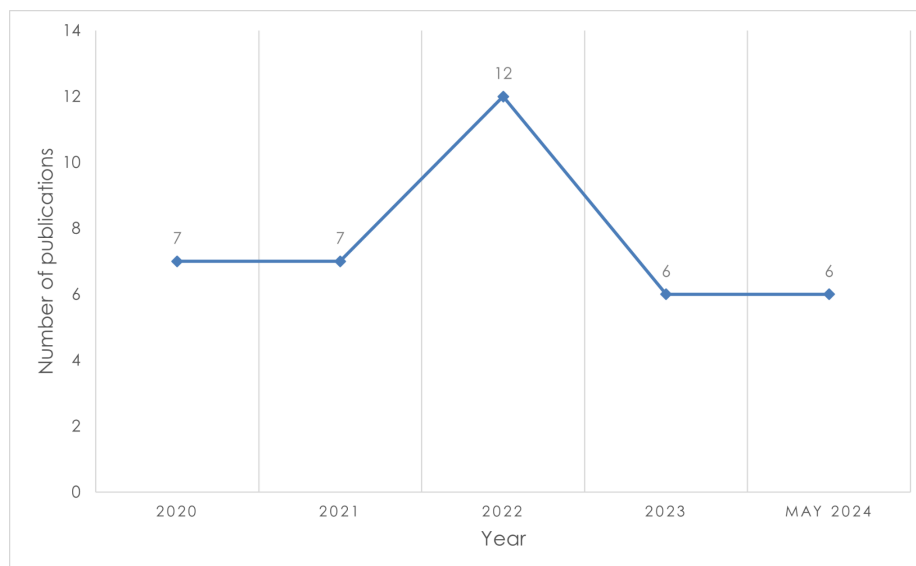


Figure 1. Distribution of research publications over the past five years (2020-2024)

What are the purposes of using AI in education, and who is the target audience? (RQ1)

Concerning the first research question which is about the purpose of using AI in education we retrieved six (6) categories. Here's an overview of the retrieved categories:

Learning efficiency and effectiveness: studies that look into ways to make learning more efficient and effective. These studies might explore methods to boost student engagement and performance, assess the impact of different teaching approaches, and examine how AI can streamline educational activities. The common space of these works is to optimise both the learning environment and instructional methods to achieve better educational outcomes.

Performance prediction: studies that deal with using AI for predicting learners' performance including key performance indicators and improvement potential. Research under this category includes training of models to predict performance and potentially provide recommendations based on these predictions of future outcomes.

Performance improvement: studies focused on improving learners' performance. This category extensively covers techniques for improving performance and student engagement.

Learning outcomes prediction: studies focused on predicting learning outcomes with the use of AI tools. Such outcomes are cognitive skills or soft skills that are potentially developed.

Student dropout prediction: studies aim to predict, with the use of AI techniques, learners' dropout rates. It includes predicting the possibility of dropout as well as adapting strategies to reduce failure and dropout rates. The focus on identifying at-risk learners and implementing preventative measures makes this category special. We considered this category to be separate from the "Performance Prediction" category because of its high frequency of occurrence among the papers we analyse and the importance that the scientific community assigns to this category.

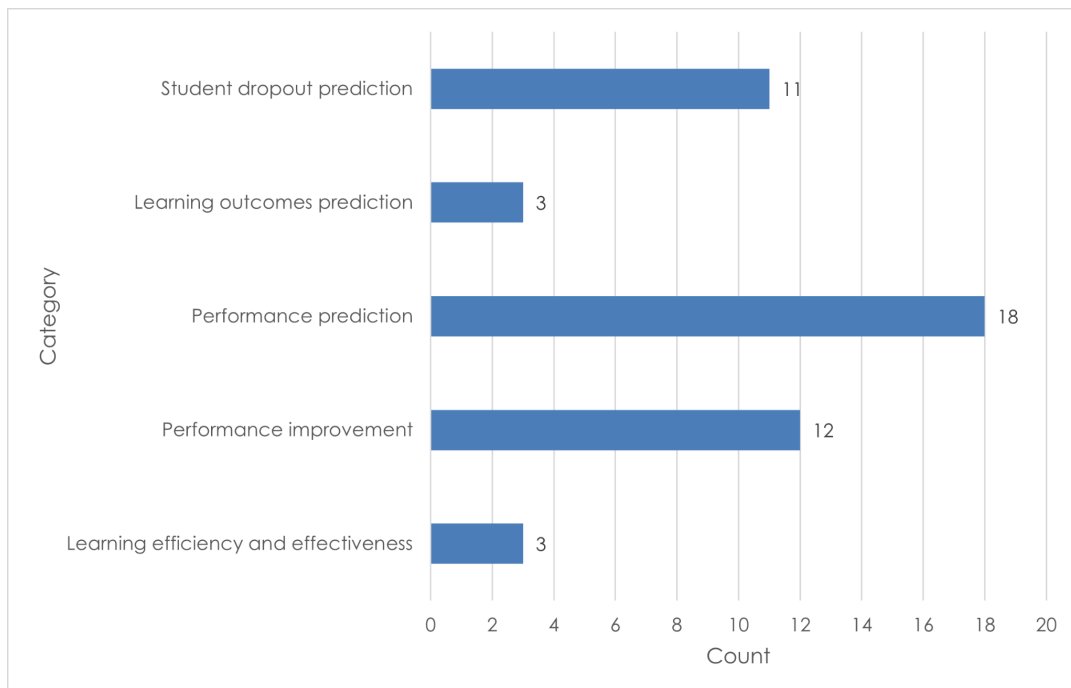


Figure 2. Number of publications per Category (Purpose of AI use)

Concerning the above categorization, the analysis of our data revealed some interesting trends. First, we should note that some tasks may belong to more than one category. Most notably, “Performance prediction” stands out, with eighteen (18) papers focusing on how AI can forecast student performance and guide educational strategies. This outcome shows a significant interest in using predictive analytics to improve education. “Performance improvement” is also a key category, with twelve (12) papers discussing how AI can boost student performance and engagement through personalised recommendations and targeted support. The “Student dropout prediction”, founded in eleven (11) papers, is another important highlight, exploring how AI can identify at-risk learners and help keep them engaged. Categories “Learning efficiency and effectiveness”, and “Learning outcomes prediction”, each have three (3) papers. These areas look at optimising the learning process and anticipating specific academic results. Overall, the data indicates a strong emphasis on the predictive analytics power of AI in education, especially in terms of performance and retention, while also recognizing the value of improving and understanding different educational outcomes.

Next, we investigated the target groups to which the surveys refer. In our review, we found that most of the studies, a total of thirty-five (N=35) out of thirty-eight (N=38) (92%), focused on higher education learners, with only three (N=3) studies (8%) addressing learners without specifying their educational level. In addition, two of the above studies focused on the attendance of Massive Open Online Courses (MOOCs) by the target group. This fact

highlights the growing importance of MOOCs in education and the potential they offer in the use cases of AI systems.

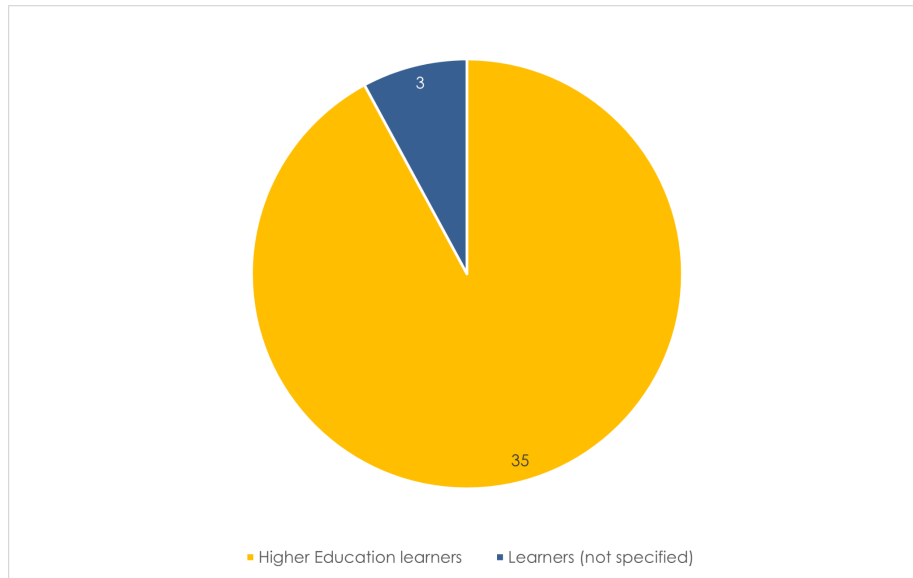


Figure 3. Target audience

The focus on higher education can be attributed to many factors. Higher education learners often have more complex and diverse learning needs, which require advanced AI systems to deliver personalised learning paths, detailed analytics and adaptive learning technologies. Universities and colleges generally have more resources, including funding and access to technology, making it easier to adopt and experiment with AI systems. Researchers also prefer to focus on higher education because of easier access to willing participants.

Which pedagogical frameworks or pedagogical aspects are supported by AI techniques in education? (RQ2)

In order to answer this research question about the pedagogical contexts or aspects of the studies, we retrieved seven (N= 7) categories from our data. Here's an overview of the retrieved categories:

Personalised learning explores how AI can tailor educational content and experiences to match learners' individual needs, preferences, and learning styles. These studies include the development and evaluation of AI systems that provide personalised feedback, learning materials that adapt to student needs, and personalised learning paths.

Adaptive learning explores AI-based approaches that adapt learning content and activities in real-time based on student performance and engagement. The research

included here concerns the development and testing of adaptive learning systems that modify lessons, quizzes, and assignments to better suit each learner's pace and understanding. Emphasis is placed on real-time adaptation and dynamic adaptation of training material.

Blended learning category investigates how artificial intelligence can integrate and enhance both online and traditional face-to-face learning environments. The studies here focused on developing artificial intelligence tools that personalise online content, track student progress in different ways, and facilitate seamless transitions between online and offline learning activities. This category examines the optimization of the combination of digital and in-person educational methods.

Flipped classroom explores the role of artificial intelligence in supporting the flipped classroom model where learners learn new content online outside of class and engage in interactive activities during class. The research explored AI applications that personalise learning materials outside of the classroom, track student engagement, and provide insights into classroom activities. The focus is on enhancing the effectiveness of this educational approach through artificial intelligence.

Collaborative learning category focused on how artificial intelligence can support and enhance collaborative learning environments. The studies included here involved artificial intelligence tools that facilitate teamwork, promote peer interaction, and adapt to student collaboration dynamics. The research explored how AI systems can monitor and analyse group activities, provide real-time feedback, and support effective communication and problem-solving among learners.

Gamification category includes work that explores the integration of game elements into educational contexts with the use of AI tools. Research here focuses on how AI can integrate game-based learning activities and how it can provide adaptive game challenges and rewards to individual student performance. They also measure the impact of interventions on student engagement.

Online Project-Based Learning explores how artificial intelligence can support project-based learning conducted over the Internet. Studies have explored artificial intelligence tools that help manage projects, enhance collaboration between learners, and provide personalised feedback on project work.

It should be noted that some of the studies included more than one aspect or strategy. Most of the studies, thirty-four (34) in total, focus on Personalized Learning, highlighting its importance in adapting educational experiences to meet the particular needs of each student. Another key area is "Adaptive Learning", with twelve (12) studies where, as

mentioned above, it looks at how artificial intelligence can adjust educational content in real time based on student performance. Blended learning and flipped classroom approaches are also notable, with four (4) and two (2) studies, respectively, showing how AI can integrate and optimise both online and in-person learning environments. Additionally, we found that AI is used in Cooperative Learning and Gamification, each supported by one (1) study, to facilitate peer-to-peer interactions and introduce game-like elements for increased engagement.

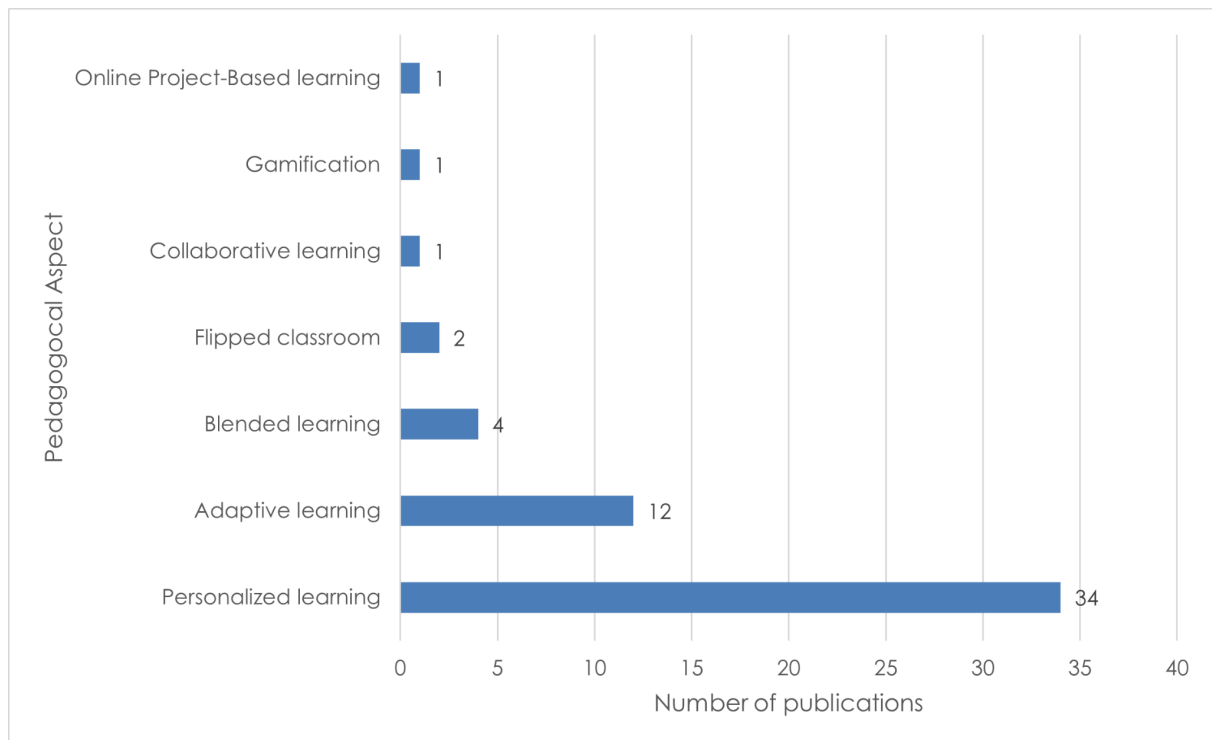


Figure 4. *Pedagogical aspects that supported by AI techniques in education*

A study also explored the role of AI in online project-based learning, demonstrating its potential in managing and enhancing project-based online education.

Interestingly, none of the studies referenced established pedagogical frameworks but instead, they focused on specific aspects, approaches, and strategies where AI can significantly impact educational outcomes. This may happen because AI in education needs interdisciplinary collaboration between educators, technologists, and data scientists. This collaboration can lead to the development of unique strategies and aspects that don't necessarily fit into traditional educational frameworks but are effective in achieving educational goals.

What types of outcomes (cognitive outcomes, soft skills, behavioural outcomes) are introduced in AI-enhanced educational environments? (RQ3)

The study investigates the association between learning patterns and their learning outcomes, contributing to understanding the impact of AI-enhanced learning environments on learning performance.

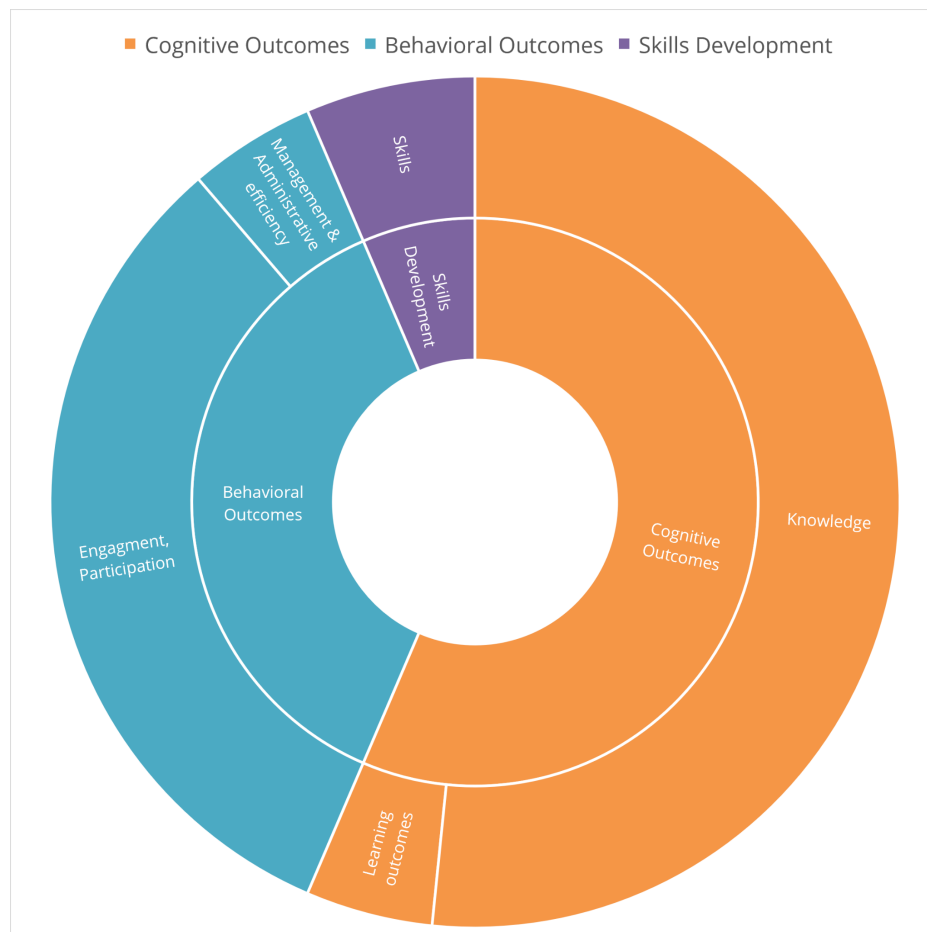


Figure 5. Categories of outcomes in AI-enhanced environments

Based on our analysis, we can conclude that AI-enhanced learning environments primarily affect “**Cognitive Outcomes**”. More specifically, as it appeared in thirty-two (32) papers, they affect the acquisition of knowledge. General learning outcomes were highlighted in three (3) papers, highlighting how broader cognitive development appears to be facilitated by artificial intelligence tools. In the large “**Behavioral Outcomes**” category, engagement and participation, with twenty (20) tasks is an important outcome due to the integration of AI. Finally the third major category “**Skill Development**” was examined in four

(4) papers, indicating less focus compared to the other two major outcome categories. The findings reveal that while AI effectively enhances knowledge and participation, there is a need for further research into skill development. Future research should also explore different educational settings (e.g., vocational education, school education) to understand the unique effects of AI in different learning environments. Overall, AI-enhanced environments offer significant benefits to cognitive and behavioural learning outcomes.

How can educational AI applications be classified into categories based on techniques and methodologies? (RQ4)

This question about the AI domains classification pointed out ten (N=10) categories. The same question was investigated in the other SLR of the project (Deliverable 2.1- Pilots Definition and User Requirements Analysis/2 State-of-the-art: Artificial Intelligence in Education from a technological perspective) which as mentioned is considered a general state-of -the-art about the use of AI in education, including various aspects of AI applications. The results of that query are partially verified here as almost the same categories emerge. Any differences mainly concern the different categorization that was followed. Also an important role in these small differences may have played the fact that our SLR concerns research in which there is always an LMS that has the ability to collect data, which may lead the research to use prediction techniques more.

While these categories are distinct in our research, there are overlaps and relationships between them, with some being subdomains or specific applications of broader techniques within the field of machine learning and artificial intelligence. Here's an overview of the retrieved categories:

Machine learning algorithms and techniques: by examining different research works, we learned that these algorithms play a key role in shaping adaptive learning environments that cater to the unique needs of each student. When machine learning is integrated into educational platforms, it allows for instant feedback, which keeps learners more engaged and ultimately makes learning more enjoyable and effective.

Deep learning techniques: we noticed a major shift in these techniques to help in forecasting student outcomes and also support the creation of intelligent tutoring systems that support learners.

Neural networks and their variants: convolutional neural networks are shown to be effective in language processing tasks, while recurrent neural networks are used to streamline automated grading systems.

Clustering and unsupervised Learning: these methods help educators uncover hidden patterns in student data, which can lead to more focused teaching strategies.

Chatbots and conversational agents: this category highlights the effectiveness of chatbots like ChatGPT in offering quick support to learners. These AI-powered tools provide personalised tutoring and help with administrative tasks, which overall enhances the learning experience. There is a significant potential of chatbots in creating more interactive and engaging learning environments.

Intelligent tutoring systems (ITS): research suggests that ITS can greatly enhance learning paths and boost student achievement.

Educational data mining: highlighted its importance in drawing valuable insights from educational data. With data mining techniques, educators can spot learners who may be at risk, forecast future performance, and refine instructional designs. The research underscores the potential of educational data mining to support informed decision-making in the education sector.

Time series and forecasting: these methods help educators make informed decisions and allocate resources more effectively.

Recommender systems: by examining past interactions and performance, these systems provide customised recommendations that boost student engagement and success. The research indicates that recommender systems could significantly transform education by enabling tailored learning journeys.

Ensemble learning and model stacking: techniques in education is the category where with the combination of multiple models, researchers aim to achieve higher accuracy and reliability in educational predictions. The findings suggest that these techniques have the potential to enhance predictive models used for student assessment and personalised learning suggestions.

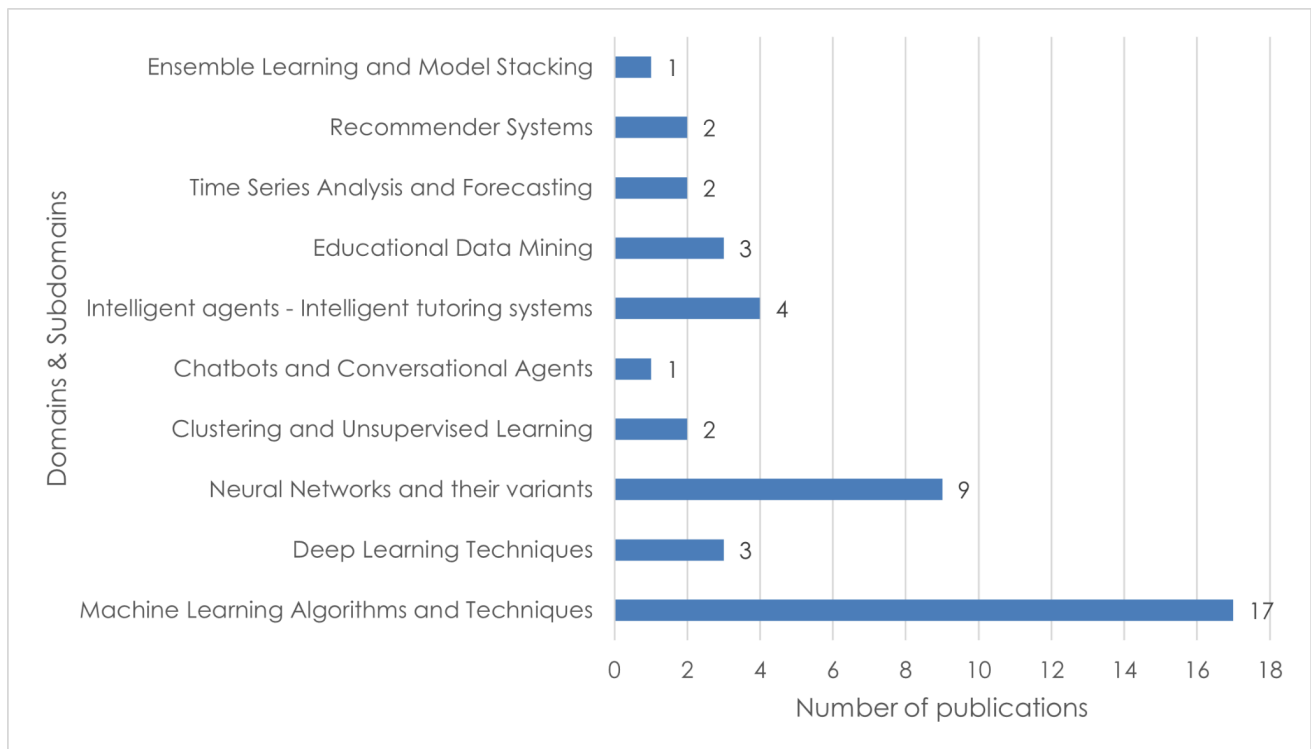


Figure 6. Classification of educational AI applications based on techniques and methodologies

Regarding the frequency of occurrence, traditional machine learning algorithms and techniques appeared as the most frequently mentioned category (N=17), thus showing the research's emphasis on personalising education and improving learning outcomes. Also deep learning techniques (3), and especially neural networks and their variants (N=9), have shown considerable interest in data analysis for educational purposes. In addition, clustering and unsupervised learning techniques, although less common (N=2), reflected a growing interest in uncovering hidden patterns in training data. Somewhat surprising is that chatbots and conversationalists appeared rarely (N=1), suggesting the need for further research. Intelligent teaching systems (N=4) appeared with moderate frequency. Training data mining (N=3), time series analysis and forecasting techniques (N=2), as well as recommender systems (N=2), also present a potential. Ensemble learning and model stacking techniques, while appearing only once, could play a role in improving predictive accuracy in educational contexts. Overall, our analysis highlights the multifaceted role of artificial intelligence in education, across a range of categories that are being studied for their potential to optimise teaching and learning experiences.

The table below (Table 1) captures the findings of the research questions from the systematic literature review.

Table 1. Research Questions and main outcomes

RESEARCH QUESTION	MAIN OUTCOME
RQ1: What are the purposes of using AI in education and who is the target audience?	AI is used to enhance learning efficiency and effectiveness, to predict and improve performance, predict learning outcomes, and reduce student dropout rates. Most studies focus on higher education learners and some of them use Massive Open Online Courses as a learning tool.
RQ2: Which pedagogical frameworks or pedagogical aspects are supported by AI techniques in education?	No established pedagogical frameworks were identified; instead, studies focused on specific aspects where AI impacts educational outcomes. AI requires interdisciplinary collaboration for developing effective educational strategies.
RQ3: What types of outcomes (cognitive outcomes, soft skills, behavioural outcomes) are introduced in AI-enhanced educational environments?	AI primarily affects cognitive outcomes (knowledge acquisition), behavioural outcomes (engagement and participation), and to a smaller degree, skill development. Further research is needed in skill development and varied educational settings.
RQ4: How can educational AI applications be classified into categories based on techniques and methodologies?	AI applications are classified into machine learning algorithms, deep learning techniques, neural networks, clustering, chatbots, intelligent tutoring systems, educational data mining, time series analysis, recommender systems, and ensemble learning.

2.4 Main conclusions

The conclusions derived from our research verify the impact of AI on Education and the necessity of the project's objectives. The most important conclusions are:

Impact of AI on education:

As shown in research, AI significantly contributes to improving **learning efficiency, predicting and enhancing student performance, and personalising educational experiences**. These advancements help in creating more engaging and effective learning environments. This finding aligns with the general targeting of the project in which all these are implemented through an **AI-boosted learning environment**. A very strong admission of the augMENTOR

project's aim is the power of the learning management system to gather demographics and learning and behavioural data for learners in various ways. The intermediate layer that the project is adding for analysing, predicting and adapting learners' performance is an innovation for education today.

Lack of established Pedagogical Frameworks:

The reviewed studies do not focus on the **integration of AI** in established pedagogical frameworks but focus mainly on specific **pedagogical aspects, approaches and strategies**. This suggests that while the need to use AI at all stages of the educational process has been recognized, its integration into pedagogical models is still unexplored. This finding aligns with the overall goal of the **augMENTOR project** to integrate emerging technologies into education and training through **a new pedagogical framework that emphasises both technological and pedagogical dimensions equally**. augMENTOR specifically developed a digitally enhanced pedagogic framework that builds on creative pedagogy principles and extends established models (T-Pack model) to meaningfully incorporate artificial intelligence, addressing the gap highlighted in the reviewed studies.

Focus on all educational levels:

The majority of the research **focuses** on **higher education**, highlighting the potential of AI to address the unique needs and challenges of this educational level. Except that it should be mentioned that we didn't manage to find a solution that will be global to all the educational settings and levels. It seems that future research should also explore different educational settings (e.g., vocational education, school education) to understand the unique effects of AI in different educational levels. The augMENTOR project's **innovation** is that the proposed pedagogical framework and the proposed AI-boosted learning system **do not focus** on any **specific educational level** (e.g. tertiary education) or context (e.g. formal education). Both tools, the framework and the technological tool are **universal** and concern different educational levels and settings. To reinforce all that has been said, it should be noted that the pilot tests of the project include testing in different contexts (vocational training, higher education, school education, local education).

In conclusion, the impact of AI on education is immense, on many levels. Perspectives that open up are improving learning efficiency, predicting and improving student performance, and personalising educational experiences. However, **there is a notable gap in the integration of AI into existing recognized and widespread pedagogical frameworks**. The research shows that all studies focus on specific aspects and strategies and not on comprehensive models. In addition, the application of artificial intelligence in education focuses on higher education, highlighting the need to further explore its application at other levels as well.

3 augMENTOR Pedagogical Framework

3.1 Introduction

Our SLR in the previous section confirms AI's significant impact on education by improving learning efficiency, predicting and enhancing student performance, and personalising educational experiences, which aligns with our project's goal of an AI-boostered learning environment. However, studies reviewed highlighted a gap in integrating AI within established pedagogical frameworks, focusing mainly on specific aspects and strategies. This supports augMENTOR's aim and specifically D3.1 goal to propose a novel pedagogical framework that integrates AI and emerging technologies, building on creative pedagogy principles and extending established models like the TPACK model.

Additionally, according to the requirements elicitation via stakeholder analysis which were elicited in D2.1 (section 5.4.3 User requirements) seven (7) thematic requirements for the augMENTOR Pedagogical Framework need to be addressed and are briefly outlined below.

1. Adaptive Learning and Skill Development

Focuses on personalised education tools that adjust **content** based on **learners' skills**, providing real-time **assessment, feedback**, and tracking of skill development. Enhances engagement and comprehension through interactive learning experiences.

2. Inclusivity and Accessibility

Emphasises educational tools that cater to **diverse learners**, ensuring equal access in varying connectivity settings. Supports bridging educational disparities through adaptable solutions.

3. Learning Analytics and Personalized Feedback

Utilises data-driven insights for **pre-assessment, content customization, progress monitoring, and personalised feedback**. Enhances **learner-centred education**, improving educational quality and relevance.

4. Monitoring Motivation and Engagement

Focuses on enhancing learners' motivation and engagement through **learning strategies** fostering intrinsic motivation and active participation. Addresses challenges in content creation and sustaining learner interest.

5. Continuous Improvement and Reflective Teaching

Centres on **educators' continuous improvement** through self-reflection and iterative adjustments. Uses pre-assessment, regular feedback, and **AI tools** to refine **teaching methods** for impactful **learning outcomes**.

6. Integration of AI in Pedagogical Frameworks

Aims to integrate AI into educational models, balancing **technological innovation with pedagogical practices**. Facilitates meaningful exchanges and enhances teaching effectiveness.

7. Effective Use of Technology in Education

Focuses on **leveraging technology** to create engaging, inclusive, and effective learning environments. Supports pedagogical interactions and reflective **learning practices** for practical educational applications.

Therefore, the augMENTOR PF must consider various learner needs, prior skills and knowledge, educators' practices, and their requirements for more effective pedagogical approaches. It should integrate AI technologies and ICT tools to enhance the learning process, content delivery, and achieve desired learning outcomes. The theoretical foundations presented in the following section address these aspects and lead to the proposal of the 7 components of the PeDeMET, detailed in section 3.2 titled "PeDeMET: augMENTOR Pedagogical Design Model with Emerging Technologies."

3.2 Theoretical foundations of augMENTOR Pedagogical Framework

The design of educational practices has become a distinct discipline within Learning Sciences (Sawyer, 2006) and Education Sciences (Schunk, 2009). Scientific research and development in this field have seen significant momentum, particularly with the rise of Digital Technologies. Over the years, a specialised academic domain has evolved, commonly referred to **as instructional design and technology and learning design and technology**. This field examines instructional design with digital technologies, encompassing both theoretical and applied perspectives (Newby, Stepich, Lehman & Russel, 2009; Smaldino, 2010; Laurillard, 2012). Specific models, such as the ASSURE(**A**nalyze and Assess Learners, **S**et Clear Objectives, **S**elect Appropriate Technology, **U**se Technology Effectively, **R**equire Active Participation, **E**valuate and Revise) (Heinich et al., 1999), inherently integrate technology into their frameworks. Consequently, a new trend is emerging in approaches to the design of teaching and learning, where digital technologies are considered an integral component of the contemporary educational process.

In this document, we present our unique perspective on the design of teaching and learning, introducing a novel framework that transcends the traditional one-sided emphasis on either the educator or the content (Instructional Design) and the learner (Learning Design). Instead, we propose a more comprehensive model that considers the entirety of human activity involved in the pedagogical process. We refer to this model as the **Pedagogical Design Model with Emerging Technologies (PeDeMET)**.

The **PeDeMET** is a new model for designing teaching and learning processes. The theoretical aspect of the design process incorporates insights from modern learning science and educational technology, merging them into a coherent framework for designing effective teaching and learning experiences. On a practical level, the goal is to generate an educational product delineating the structure of a teaching intervention, providing explicit guidance for both educators and learners to attain predefined learning objectives. This tangible outcome of Pedagogical Design adheres to the **Technology - augmented Educational Scenarios and e-Activities (TESA)** approach and we will call it **Educational Scenario with Digital Technologies** (Komis, 2019).

The **augMENTOR Pedagogical Framework** and the two (2) models that specialise it at the macro level (**PeDeMET**) and at the micro level (**TESA**) derive their conceptual tools from three (3) theoretical frameworks, which are then amalgamated into a unified framework for describing, analysing, and evaluating the teaching and learning process (Figure 7):

- The enriched Pedagogical Triangle with Digital Technologies (Komis, 2019),
- Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006) and
- The Cultural and Historical Activity Theory (CHAT) (Kaptelinin & Nardi, 2006).

augMENTOR Pedagogical Framework theoretical foundations

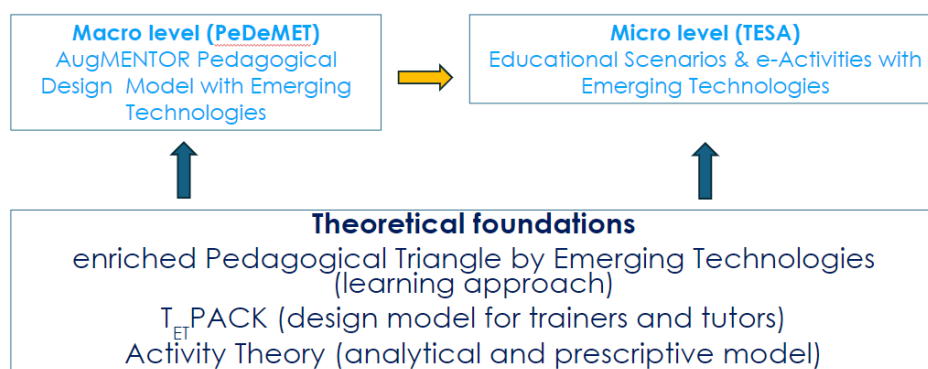


Figure 7. Components and foundations of augMENTOR Pedagogical Framework

A key element of this process is the Activity which is considered as the unit of analysis.

3.3 PeDeMET: augMENTOR Pedagogical Design Model with Emerging Technologies

Drawing from the characteristics of the three (3) aforementioned theoretical frameworks (see ANNEX 2: The theoretical foundations of augMENTOR: The enriched Pedagogical Triangle with Digital and Emerging Technologies, ANNEX 3: The theoretical foundations of augMETOR: The enriched Pedagogical Triangle with Digital and Emerging Technologies: TPACK, ANNEX 4: The theoretical foundations of augMETOR: CHAT), a pedagogical design model must effectively organise the activities undertaken by both educators and learners. This model represents human activity within formal educational settings such as classrooms, schools, universities, as well as distance or hybrid learning environments. Emphasising the entirety of activity rather than solely focusing on individual participants (be they learners or educators) appears to mark a novel approach within the domain of pedagogical design. This approach stands apart from design methodologies that are centred around educators, content, or technology. (Goodyear, 2019; 2020).

To achieve this, the model must, among other things:

- a) Analysing the needs (both didactic and cognitive) of these participants concerning the activity undertaken and the environment in which it occurs, thereby addressing both teacher-centred and learner-centred concerns (in alignment with D3.3, section 3.2 “The Cognitive Domain”, and D2.1 section 5.4.3 User requirements).
- b) Appropriately delineating the educational content (object) of these activities, encompassing the knowledge that learners are required to engage with, thus adopting a knowledge-centred approach in alignment D2.1 section 5.4.3 User requirements, and the seven (7) thematic requirements presented above.
- c) Focusing on the utilisation of tools (whether physical or symbolic) that mediate these activities, emphasising their overall value based on both their technological and pedagogical potential, as mentioned above in the seven (7) thematic requirements, as AI and ICT tools.
- d) Identifying the outcomes of teaching and learning activities using assessable terms, clarifying that these outcomes encompass not only knowledge acquisition but also the strategies (e.g., the 4Cs, creativity, critical thinking, communication, collaboration) employed to achieve them (alignment with D4.1, 3. “State-of-the-art of the 4Cs”)
- e) Determining the teaching/learning methodologies (including those related to the 4Cs) through which the anticipated outcomes of the teaching and learning activity will be realised (alignment with D4.1 and specifically, section 2. “Creative pedagogies to support the augMENTOR project”).

- f) Describing the procedures for both formative and summative assessment of learning outcomes and the overall activity, as mentioned above in the seven (7) thematic requirements, as appropriate assessment and feedback to the learners.
- g) Situating teaching and learning activities within the broader school and social environment in which they occur, acknowledging their potential impact on these environments.

In this context, the **PedeMET** organises the pedagogical activity based on seven main components and their individual interactions (Figure 8):

1. **Outcome (knowledge and competencies) of activity**
2. **Course content (the object of activity)**
3. **Learners**
4. **Tutors**
5. **Emerging Technologies**, which mediate the activity of learners and tutors
6. **Learning strategies**, which organise and direct the pedagogical activity
7. **Evaluation**, which concerns both learning outcomes and the development of the activity.

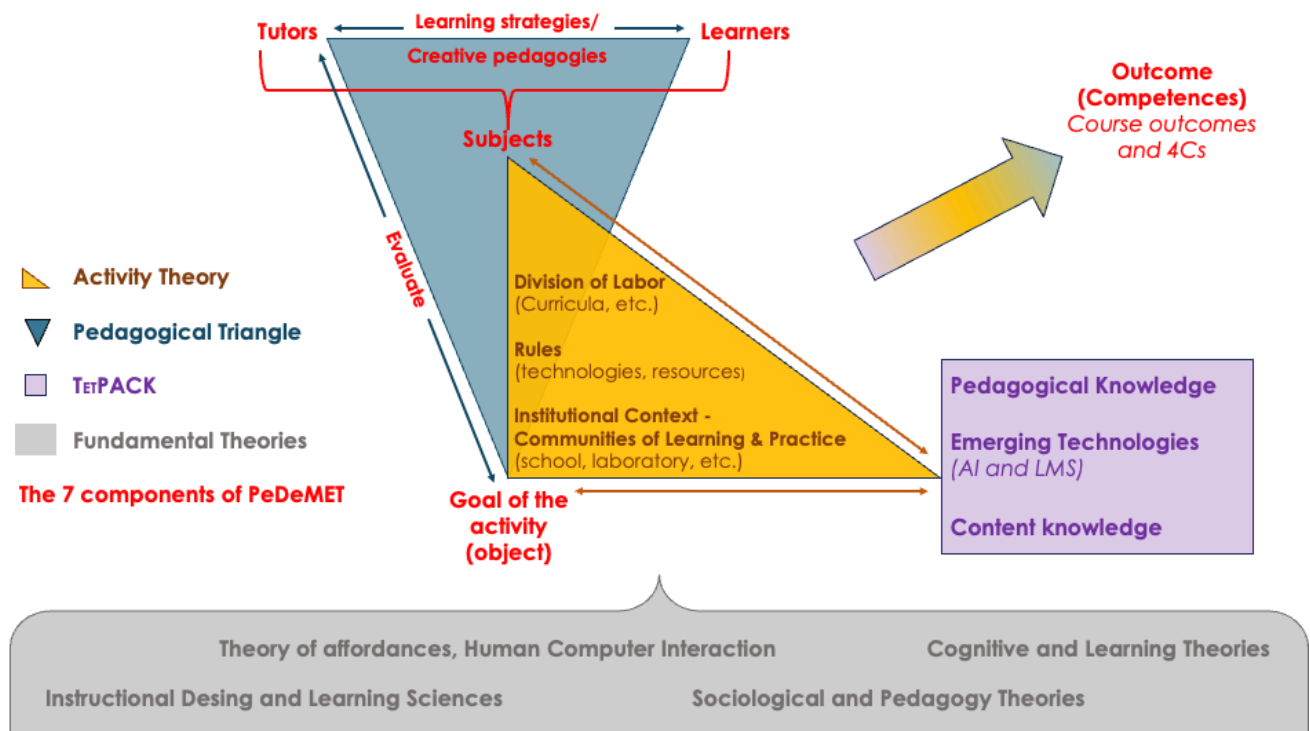


Figure 8. Pedagogical Design Model with Emerging Technologies (PedeMET)

As shown in Figure 8, the interactions between the individual components are organised by:

a) the **Pedagogical Triangle** (green triangle) which can be enriched with Emerging Technologies and b) the **Activity Theory** (yellow triangle), which helps to design the activity of learners and tutors. At the same time, **the T_{AI-LMS} PACK model** identifies effective approaches for integrating Learning Management Systems (LMS), incorporating AI tools, into the structure and progression of pedagogical activities, while considering the anticipated outcomes and the demands of the subject matter (course content). Finally, it should be mentioned that it goes without saying that the model is based on findings from Cognitive and Learning Theory (alignment with D3.3, the learner model theoretical foundation), Learning Sciences, etc.

PedeMET (Pedagogical Design Model with Emerging Technologies) outlines the overarching design principles (described as the 7 components of the activity in the PeDeMET) and the interconnections between these principles. However, it does not delineate the specific phases of the process involved in designing and executing pedagogical activities in real-world settings, nor does it delve into their evolution. Additionally, it does not detail the roles of the participants in the activity, nor does it explore the methods of utilising Emerging Technologies or the tools and procedures for evaluation. In essence, it does not serve as a model for planning and analysing the day-to-day pedagogical Activity and its progression. These issues, as we have already mentioned, are described by the **TESA (Technology - augmented Educational Scenarios and e-Activities)** approach. **TESA** therefore specifies the design and application of **PedeMET** at the classroom level (define and apply classroom activity). It is a model for designing and implementing **Educational Scenarios** and **pedagogical e-Activities**.

In the rest of the deliverable, the concepts of **Educational Scenario** and **pedagogical e-Activity** as processes and products of **PedeMET** will be presented. The primary focus will be on the practical level, emphasising the role of the teacher in designing classroom pedagogical activities using Emerging Technologies (such as AI and LMS). **TESA** serves as both a product, stemming from pre-analysis, and a process wherein the teacher utilises the product (in this instance, the Educational Scenario) by customising it to suit the dynamics of their classroom.

3.4 TESA: Technology - augmented Educational Scenarios and e-Activities

The **educational scenario** is the main concept of **PedeMET**. The term "educational scenario" refers to the outcome of a planning procedure tailored to a particular educational subject. Unlike the conventional "lesson plan" used in traditional instructional design, "educational scenario" signifies the alternative approach embraced by pedagogical design. Also, the

educational scenario differs significantly from the lesson plan in several key aspects see table 2 below:

Table 2. *Educational Scenario vs Traditional Lesson Plan*

Aspect	Lesson Plan	Educational Scenario
Theoretical Framework	Behaviourist approach	Emphasises constructivist and collaborative strategies
Content and Process	Specific and mechanistic organisation	Considers cognitive difficulties and alternative representations
Goal-Setting	Teacher-centred with defined objectives	Includes diverse teaching strategies for collaboration and constructivist learning
Needs Analysis	Often overlooks learners' cognitive challenges	Centralises learners' cognitive difficulties and alternative representations

According to modern Learning Science, *educational scenarios* are effective pedagogical tools that support educators in their instructional practice (Komis, 2019). These scenarios are flexible and adaptable to the unique conditions and social dynamics of each classroom. Notably, for many computing environments used for educational purposes, particularly Emerging Technologies, there are no pre-existing scenarios. Due to the complexity of educational practice and the specific needs of each classroom, educators often need the capability to adapt or create their own educational scenarios. Therefore, developing the ability of educators to adapt existing educational scenarios or create new ones using Emerging Technologies to meet their actual teaching needs is a crucial aspect of teacher training.

An augMENTOR **Educational Scenario** designing teaching and learning activities with emerging technologies involves engaging tutors and learners, employing suitable learning strategies, and aiming to achieve specific learning outcomes using appropriate technologies (such as AI and LMS). This process is designed to facilitate the teaching and learning of specific content or 21st-century competencies (like the 4Cs). Therefore, in a

modern teaching context, an augMENTOR educational scenario integrates emerging technologies to teach and learn key concepts of a subject within the existing curriculum, while also fostering high-level competencies, such as 21st-century skills. Furthermore, the scenario can take an interdisciplinary or transdisciplinary approach to various subject areas and may also cover concepts outside the standard curriculum.

An educational scenario comprises of:

- teacher instructions
- the theoretical framework supporting the approach
- essential materials for implementation
- "activity sheets" for learners, and
- possibly additional resources (such as constructions, printed materials, or software files).

Essentially, an educational scenario is carried out through a series of learning activities. In other words, it represents a comprehensive teaching intervention with a defined purpose, objectives, challenges, an implementation process that includes appropriate activities and teaching strategies, and an evaluation process.

At this point it's crucial to explicitly highlight that the TESA framework is the central factor that ensures alignment across WP3, WP4, and WP5. This information derived from TESA serves as the practical foundation for selecting indicators and designing data-driven metrics in D3.3 and WP5, respectively. If confirmed, it's crucial to explicitly highlight this as the central factor that ensures alignment across WP3, WP4, and WP5, for more details see ANNEX 6: The augMENTOR approach - Alignment with the augMENTOR solution, and and Filippidi et al. (2023).

Axes for designing an educational scenario with Emerging Technologies

The basic quality standards of an educational scenario according to modern theories of knowledge and learning follow five major axes (Komis, 2019)

Subject of the Scenario

Regarding the problematic of educational scenarios according to contemporary pedagogical theories (such as constructivist and socio-cultural approaches), the scenarios should:

- Highlight the wide range and variety of tools and services offered by Emerging Technologies in Education and their added value in the educational process.

- Emphasise the selection criteria for qualitatively appropriate Emerging Technologies, focusing on their added value.
- Promote the interdisciplinary approach to concepts and methods with the support provided by Emerging Technologies.
- Highlight the importance and potential of learning communities facilitated by Emerging Technologies in the context of the Knowledge Society school.

Content and Format of the Scenario

Regarding the content and format of educational scenarios, they should:

- Specialise in different subjects (e.g., science, mathematics, language) and specific parts of the Curriculum where Emerging Technologies can act as cognitive tools.
- Support exploratory and discovery-based learning situations across all subjects.
- Encourage problem-solving, decision-making, and critical thinking activities in all subjects.
- Support symbolic expression, communication, and information-seeking activities where necessary, such as in language and written expression.

Teaching Methodology

In terms of teaching methodology, educational scenarios should:

- Develop appropriate knowledge and skills for educators to manage educational applications effectively, considering the changes Emerging Technologies bring to the student-teacher-knowledge relationship.
- Foster a critical attitude among educators toward the didactic use of emerging technologies, recognizing that not all are equivalent from a teaching and learning perspective.
- Encourage reflection on the transformation of the roles of the main actors in a learning process (learner, educator, knowledge, computing environment) and the changes in educators' work, such as how knowledge is mediated and how learning outcomes are assessed with emerging technologies.

Learning Strategies

Regarding learning strategies, educational scenarios should:

- Facilitate the use of Emerging Technologies in the teaching and learning process while promoting new, alternative forms of teaching aligned with modern pedagogical and teaching theories and Digital Technologies.
- Support the transition from face-to-face teaching to group teaching and cooperative learning.

- Shift from teacher-centred teaching where Emerging Technologies are used as supervisory tools to student-centred teaching where Emerging Technologies are used as cognitive tools.
- Transition from lecture-based teaching methods to exploratory and discovery methods.
- Move from passive to motivated classrooms through active participation, student communication, and authentic activities.
- Replace single final test-based assessments with methods based on processes and products produced by learners.
- Enable a system where learners learn different things instead of everyone learning the same things.
- Incorporate multiple modes of communication, including multiple representations, images, texts, symbols, maps, and linked representations.

Use of Emerging Technologies

Regarding the use of Emerging Technologies, an educational scenario that utilises these technologies should foster the development of high-level competencies, including:

- Problem-solving skills.
- Development of critical thinking.
- Ability to explore and search for information across a wide range of data.
- Development of decision-making skills.
- Ability to model real-world phenomena and situations.
- Ability to collaborate and jointly approach and solve problems.
- Interdisciplinary approach to knowledge.
- Skills to transfer knowledge from one context to another.

In summary, augMENTOR educational scenarios emphasise the design and implementation of pedagogical activities that foster the development of high-level cognitive competencies, which are transversal to the curriculum. These include problem-solving, experimental processes, exploration and discovery activities, modelling, interdisciplinary approaches, decision-making, critical thinking, reflection, and neo-critical literacy. Neo-critical literacy is an advanced approach that integrates insights from disciplines like sociology and critical theory. It goes beyond traditional literacy by exploring diverse forms of communication, including digital media. It empowers learners to critically analyse and challenge social inequalities and dominant ideologies. This approach values cultural diversity and promotes global perspectives, fostering reflective thinking and actions for social change.

Development phases of the educational scenario with Emerging Technologies

As we have seen in the previous section, the design of *educational scenarios with Emerging Technologies* constitutes a complex pedagogical activity, which requires knowledge related to *Technological Pedagogical Content Knowledge* and in particular

- a) the subject to be taught
- b) the teaching practice of the subject
- c) pedagogical and psychological theories of teaching and learning
- d) the technology used and in particular the added value that this technology can bring to the teaching and learning process.

It is appropriate that augMENTOR training scenarios have the following structure:

- Summary presentation of the scenario including title, estimated duration, cognitive areas involved, classes, compatibility with the curriculum, organisation of teaching, cognitive prerequisites & required material and technical infrastructure, teaching objectives (in terms of the subject matter, in terms of the use of Emerging Technologies, in terms of the learning process).
- Teaching approach (theoretical and methodological approach, teaching approach with Emerging Technologies, the problematic of the scenario, pedagogical activities, evaluation and possible extensions).

In this section we briefly present **TESA**, augMENTOR's Emerging Technologies educational scenario design model. It is a model that can be applied to all levels of education and reframes the above scenario development structure, documenting it in greater detail.

In particular, the **TESA** follows seven phases, which describe both the rationale on which a scenario using Emerging Technologies should be based (Phases A, B & C) and the way in which classroom activities are designed (Phases D & E) and how the scenario is implemented and evaluated (Phases F & G). In its final form, an eighth phase can be added to document the scenario after at least one full cycle of planning, implementation and evaluation.

This model should not be viewed as a rigid method that educators must strictly follow when designing learning activities with Emerging Technologies. Instead, it serves as a flexible framework within which educators can organise their teaching interventions, drawing on the findings of science teaching and the appropriate use of technology, while emphasising its added value.

In the context of both constructivist and sociocultural approaches to teaching and learning, there is no specific algorithm for creating educational scenarios. The diversity of educational practice and the complexity of teaching and learning processes make it

impractical to provide a detailed, step-by-step instructional plan (as often proposed by the behavioural approach) for educators to follow precisely during their instructional interventions.

However, educational scenarios generally have a stable structure. As a result, their design, development, and implementation in classroom settings can follow a series of distinct phases. These phases represent different stages in the preparation or creation of the scenario activities.

In the **TESA** model, the development of an educational scenario with Emerging Technologies includes the following relationship and interaction - eight (8) phases (Figure 9) (for more details see ANNEX 5 - TESA Framework)

Technology – augmented Educational Scenarios and e-Activities

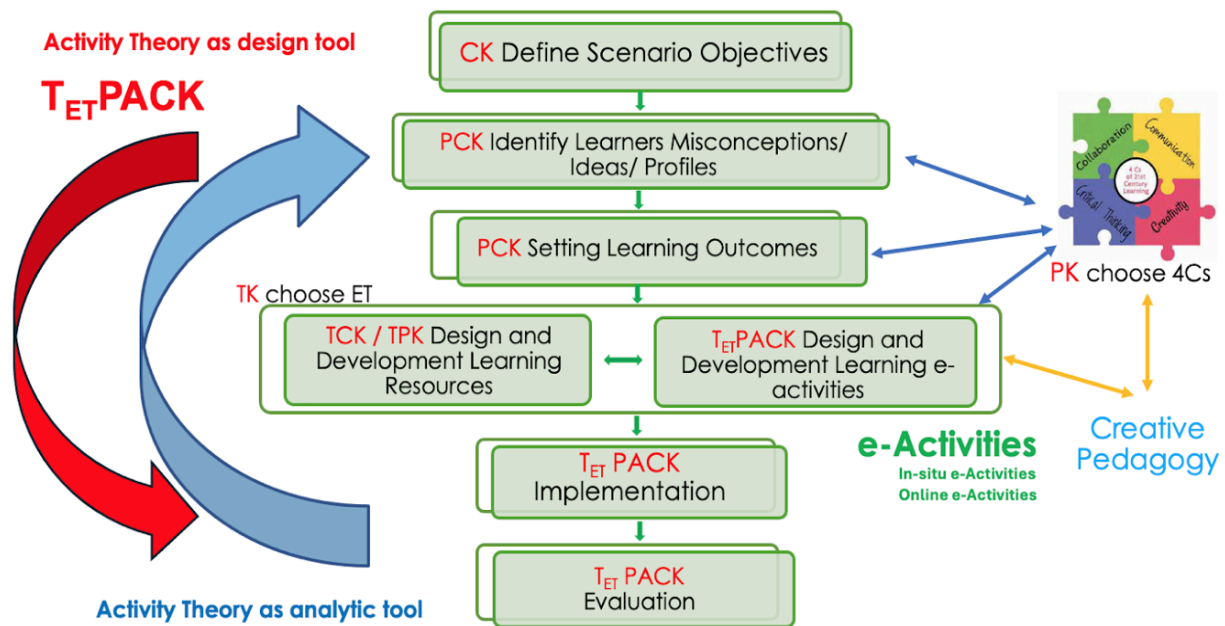


Figure 9. TESA: Phases of development of augMENTOR educational scenario

Analysis of the phases:

A. Teaching Analysis of the subject matter: The **instructional objective** of the instructional scenario (title, grade (e.g., preschool, toddler or classroom), knowledge areas involved, cognitive prerequisites, etc.)

B. Cognitive Analysis: learners' **ideas** and **representations** and possible difficulties in thinking about the subject matter

Purpose and objectives phase

C. Purpose and objectives: the **teaching and learning objectives** of the educational scenario (in terms of the subject matter, in terms of the use of ICT, in terms of the learning process)

ICT Tools & Tools Selection Phase Emerging Technologies and materials development

D. Development - Selection of Materials and Tools: the **teaching material** of the educational scenario and the required logistical infrastructure

Design and development phase of learning activities

E. Development of Learning Activities: the organisation of teaching on the basis of appropriate **activities for the implementation of** the educational scenario in the classroom (teaching approaches and strategies, utilisation of the added value of Emerging Technologies in the learning process, worksheets, etc.)

Classroom implementation and evaluation phases

F. Application in the Classroom

G. Evaluation - Review (student and scenario) and possible extensions of the scenario

Documentation phase

H. Documentation: notes and guidelines for educators / teachers, bibliography.

The previous phases are highly interdependent and typically do not develop in a strictly linear fashion, even though there is a logical sequence in their order of implementation. For example, defining the subject matter usually precedes formulating the objectives. The teaching material is closely intertwined with both the objectives and the scenario's implementation activities, often developing in parallel. Identifying prior ideas and representations influences some of the scenario's implementation activities, which may aim to reconstruct prior ideas and reshape learners' understanding of the concepts being studied.

Since the educational scenario involves the functional integration of Emerging Technologies in its implementation and application, the design should anticipate and document the use of at least one computing environment during some phases. Particular emphasis should be placed on phases related to the implementation of in-class activities, which are described in more detail in the next section.

4 Conclusions

D3.1 proposes an innovative Pedagogical Framework that studies Pedagogical and Learning Design focusing on educational activities enhanced by technology in order to create new knowledge at both macro and micro levels.

Our literature review confirms AI's significant impact on education by improving learning efficiency, predicting student performance, and personalising educational experiences. However, studies also reveal a gap in integrating AI within established pedagogical frameworks, focusing narrowly on specific aspects. This supports the augMENTOR project's aim, particularly in D3.1, to propose a new pedagogical framework integrating AI and emerging technologies, building on creative pedagogy principles and extending established models like TPACK and Activity Theory.

The augMENTOR Pedagogical Framework, along with its specialised macro-level model (Pedagogical Design Model with Emerging Technologies (PeDeMET)) and micro-level model (Technology-augmented Educational Scenarios and e-Activities (TESA)), draws its conceptual foundations from three theoretical frameworks. These frameworks are integrated to form a unified framework for describing, analysing, and evaluating the teaching and learning process.

For the macro level and according to Activity Theory, the proposed pedagogical framework includes interactions among the actors defined in the teaching triangle and the use of physical and/or symbolic tools, which include AI. These technologies are crucial for deploying the pedagogical framework.

The augMENTOR PF also expands the Technology Enhanced Learning (TEL) approach to a Technology Augmented Educational approach. Here, emerging technologies are seamlessly integrated to enhance educational activities for all participants. These technologies function both as educational tools in practice and as components for analysing and adapting teaching and learning processes through Artificial Intelligence and Educational Data Mining and Learning Analytics. The integration of the augMENTOR PF will enable real-time feedback, personalised material provision, and support tailored to educators and learners, through the augMENTOR solution.

Finally, for the micro level the augMENTOR pedagogical framework proposes a novel pedagogical framework for designing and planning technology-augmented educational scenarios. These scenarios integrate Artificial Intelligence and Learning Analytics focusing on overall classroom activity design and orchestration from the teacher's perspective. AI will serve as powerful cognitive tools for learners and decision-making and adaptation tools for educators and teachers. The framework aims to develop higher-order cognitive

competencies, such as design and critical thinking, creativity, decision making, modelling, and computational thinking.

This document targets stakeholders affected by or involved in the augMENTOR PF and its development process. This encompasses project partners participating in Work Package 3 (WP3 - "Learner Model"), WP4 - "Critical Thinking and Creativity", WP5 - "AI-boosted Blended Learning Platform", and WP6 - "Use Case Deployment, Operation, Validation, and Assessment". The outcomes of D3.1 are anticipated to contribute inputs for tasks within WP5 and WP6, while also facilitating cross-validation of the proposed framework.

References

- DeVane, B., Durga, S., & Squire, K. (2009). Competition as a driver for learning. *International Journal of Learning and Media*, 1(2). Retrieved from [http:// dx.doi.org/10.1162/ijlm.2009.0018](http://dx.doi.org/10.1162/ijlm.2009.0018)
- Filippidi, A., Karachristos, C., Lavidas, K., Komis, V., Karacapilidis, N. (2023). Leveraging Cognitive and Social Engagement in Blended Learning Through an AI-Augmented Pedagogical Framework. In: Kubincová, Z., Caruso, F., Kim, Te., Ivanova, M., Lancia, L., Pellegrino, M.A. (eds) *Methodologies and Intelligent Systems for Technology Enhanced Learning, Workshops - 13th International Conference. MIS4TEL 2023. Lecture Notes in Networks and Systems*, vol 769. Springer, Cham. https://doi.org/10.1007/978-3-031-42134-1_3
- Goodyear, P. (2000). Environments for lifelong learning: Ergonomics, architecture and educational design. In J. M. Spector & T. Anderson (Eds.), *Integrated and holistic perspectives on learning, instruction & technology: Understanding complexity* (pp. 1–18). Dordrecht: Kluwer Academic Publishers.
- Goodyear, P. (2011). Emerging methodological challenges for educational research. In L. Markauskaite, P. Freebody, & J. Irwin (Eds.), *Methodological choice and design: Scholarship, policy and practice in social and educational research* (pp. 253–266). Dordrecht: Springer.
- Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. (1999). *Instructional media and technologies for learning* (6th ed.). Englewood Cliffs, NJ: Merrill/Prentice Hall.
- Houssaye, J., 2014. *Le triangle pédagogique, Les différentes facettes de la pédagogie*. ESF, Paris.
- Komis, V. (2005). *Introduction to the didactics of informatics*. Kleidarithmos Publications.
- Komis, V. (2019). *Introduction to educational applications of information and communication technologies* (V. I. Komis, Preface). New Technologies Publications.
- Kaptelinin, Victor & Nardi, Bonnie. (2006). *Acting with Technology: Activity Theory and Interaction Design*. MIT Press: Cambridge Massachusetts.10.5210/fm.v12i4.1772.
- Koh, J. H. L., & Chai, C. S. (2014). Teacher clusters and their perceptions of technological pedagogical content knowledge (TPACK) development through ICT lesson design. *Computers & Education*, 70, 222-232.

Laurillard, D. (2012). *Teaching as a design science: Building pedagogical patterns for learning and technology*. London: Routledge.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>

Newby, T. J., Stepich, D. A., Lehman, J. D., & Russell, J. D. (2006). *Educational technology for teaching and learning* (4th ed.). Pearson.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Aki, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S.,...Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLOS Medicine*, *18*(3), Article e1003583. <https://doi.org/10.1371/journal.pmed.1003583>

Schmid, M., Brianza, E., & Petko, D. (2020). Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK. xs) and comparing the factor structure of an integrative and a transformative model. *Computers & Education*, *157*, 103967

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK) the development and validation of an assessment instrument for preservice educators teachers. *Journal of research on Technology in Education*, *42*(2), 123-149.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. <https://doi.org/10.3102/0013189X015002004>

Smaldino, S. E., Lowther, D. L., & Russell, J. D. (2010). *Instructional technology and media for learning* (10th ed.). Pearson.

Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, *33*(3).

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(1), 1–27.

ANNEX 1 - Systematic literature review methodology

We employed a comprehensive search strategy to ensure the inclusion of all relevant papers. Our initial step was to define specific search parameters, including key terms and phrases related to our research topic, such as "Artificial Intelligence " AND "Educational Level" AND "Pedagogical Framework" AND "Learning Management System". This search string derived from the work of (Zawacki-Richter et al., 2019) and was extended in order to narrow down the results. We utilised Boolean operators to refine our search, combining terms with "AND," and "OR" to narrow down the results to the online educational setting with a more pedagogical perspective. The initial search string with terms in each topic included was TS=("artificial intelligence" OR "machine intelligence" OR "intelligent support" OR "chat bot*" OR "machine learning" OR "automated tutor*" OR "personal tutor*" OR "intelligent agent*" OR "expert system*" OR "neural network*" OR "natural language processing" OR "deep learning" OR "natural language processing" OR "AI") AND ("higher education" OR college* OR "undergrad*" OR "graduate" OR "postgrad*" OR "K-12" OR "kindergarten" OR "corporate training*" OR "professional training*" OR "primary school*" OR "middle school*" OR "high school*" OR "elementary school*" OR "vocational education" OR "adult education" OR "tertiary education" OR "secondary education" OR "pre-school education" OR "technical education" OR "continuing education") AND ("pedagogical framework") AND ("learning management system*" OR "LMS" OR "course management system*" OR "online learning platform*" OR "virtual learning environment*" OR "VLE" OR "e-learning system*" OR "learning content management system*" OR "LCMS" OR "mobile learning platform*" OR "social learning platform*" OR "asynchronous learning system*" OR "synchronous learning system*" OR "student progress tracking*" OR "educational management system tool*"). The search was limited to the period from 2020 to May 2024. Unfortunately, this query did not return results in either of the two databases, a fact that led us to the conclusion that there is no literature related to the support of pedagogical frameworks by AI tools or techniques. The next step was to reformulate the query and replace the topic of the "Pedagogical framework" with a broader topic that concerns pedagogical aspects and purpose of use titled "Purpose classification". The final query is formulated as "Artificial Intelligence " AND "Educational Level" AND " Purpose Classification " AND "Learning Management System" and in Table 1 we can see the final terms used.

Table 1. Search strings

TOPIC	SEARCH TERM
Artificial intelligence	"artificial intelligence" OR "machine intelligence" OR "intelligent support" OR "chat bot*" OR "machine learning" OR "automated tutor*" OR "personal tutor*" OR "intelligent agent*" OR "expert system*" OR "neural network*" OR "natural language processing" OR "deep learning" OR "natural language processing" OR "AI"
AND	
Educational level	"higher education" OR college* OR "undergrad*" OR "graduate" OR "postgrad*" OR "K-12" OR "kindergarten" OR "corporate training*" OR "professional training*" OR "primary school*" OR "middle school*" OR "high school*" OR "elementary school*" OR "vocational education" OR "adult education" OR "tertiary education" OR "secondary education" OR "pre-school education" OR "technical education" OR "continuing education"
AND	
Purpose classification	OR "personalized learning" OR "adaptive learning" OR "student assessment*" OR "grading and feedback" OR "student engagement" OR "tutoring" OR "curriculum design" OR "course recommendations" OR "student support service*" OR "language learning" OR "special education" OR "student motivation" OR "classroom management" OR "educational games and simulations" OR "teacher professional development" OR "lesson design" OR "lesson planning" OR "assessment" OR "communication" OR "collaboration" OR "critical thinking and creativity" OR "learning outcomes" OR "performance" OR "content creation"
AND	
Learning Management System	"learning management system*" OR "LMS" OR "course management system*" OR "online learning platform*" OR "virtual learning environment*" OR "VLE" OR "e-learning system*" OR "learning content management system*" OR "LCMS" OR "mobile learning platform*" OR "social learning platform*" OR

	“asynchronous learning system*” OR “synchronous learning system*” OR “student progress tracking*” OR “educational management system tool*”
AND	
Date	2020 – May 2024

To carry out our review, we followed the PRISMA methodology (Page et al., 2021) and its procedures of identification, screening and inclusion of articles. Two faculty members worked on the screening and coding process. The two researchers met every week to discuss the process of selection. Searches were performed across two electronic databases (Web of Science - WoS¹ and Scopus²), to capture a wide array of peer-reviewed articles. The reason we did not search for papers in other well-known databases such as Institute of Electrical and Electronics Engineers (IEEE) Xplore³ and Association for Computing Machinery (ACM)⁴ was that these databases are known to contain scientific articles, research, and conference proceedings primarily in the fields of computer science, electronics, and related scientific disciplines. In trial searches on these databases, the articles returned were few in number, but most importantly, they had already been discovered in the other databases. Our search retrieved two hundred and twenty-five (N= 225) papers from Scopus and one hundred and seventy-two (N= 172) papers from Web of Science, totaling three hundred and ninety-seven (N= 397) papers. These numbers represent the initial pool of literature identified for potential inclusion in our review. It's important to note that the variation in the number of papers between the two databases could stem from differences in coverage, indexing practices, and search algorithms. These initial findings will undergo further screening and evaluation to identify relevant papers for our review.

After combining the datasets from both databases, duplicates were identified and removed. Duplicates were defined as papers with identical titles and DOIs. This process ensured that each paper was represented only once in the final dataset. Missing values were managed to the extent possible. For records with incomplete data we conducted further search where additional information was retrieved manually by checking the source journals websites. Also records with critical missing information (e.g., missing DOI or abstract)

¹ <http://webofscience.com/wos/woscc/basic-search>

² <https://www.scopus.com/>

³ The IEEE Xplore digital library is a powerful resource for discovery and access to scientific and technical content published by the IEEE (Institute of Electrical and Electronics Engineers) and its publishing partners. <https://ieeexplore.ieee.org/Xplore/home.jsp>

⁴ <https://dl.acm.org/>

that could not be resolved were excluded from the final dataset. The final dataset, with two hundred and ninety-five (N= 295) papers, is comprehensive and reliable, suitable for in-depth analysis and further research.

During the screening phase, these papers were screened by title and abstract. In this step we applied two criteria (Table 2). The first one was about excluding papers not written in English. The second criterion was to include only peer-reviewed journal articles because this kind of articles have been evaluated by independent experts in the field, which helps ensure that the research methods, data analysis, and conclusions are scientifically reliable.

Table 2. Selection criteria

	Inclusion criteria	Exclusion criteria
Screening by title and abstract	The full text can be downloaded.	The full text of the record is not available.
	The record is written in English.	The record is not written in English.
	The record is published in a peer-reviewed journal.	The record is not published in a peer-reviewed journal.
	The record involves human research.	The record does not involve human research.
Screening full-text	The record utilises AI techniques or tools in the context of online education.	The record does not utilise AI techniques or tools in the context of online education.
	The record utilises an LMS for supporting education.	The record does not utilise an LMS for supporting education.

After applying the inclusion and exclusion criteria we ended up with one hundred and ninety-nine (199) articles for full-text review. In this full-text review phase inclusion and exclusion criteria were established in order for our research to focus on studies a) presenting data on the impact of AI in education, b) utilising a learning management system for supporting the educational process, c) utilising AI techniques or tools in the context of online

education. At the end of this step we ended up with thirty-eight (38) articles⁵ for the inclusion stage. In Figure 1, the number of records throughout the different phases of the review process is presented.

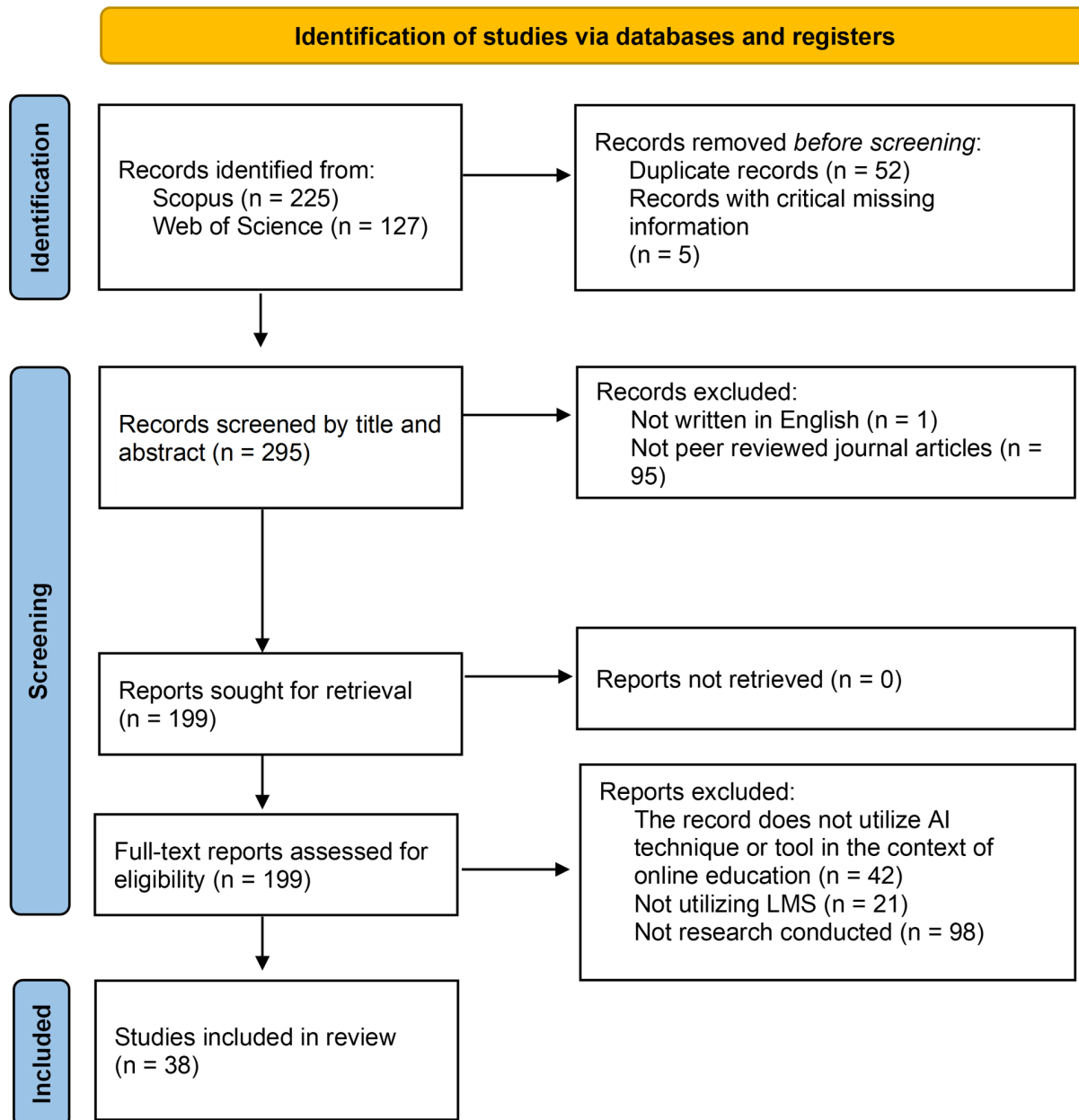


Figure 1. Process flow using Prisma

⁵<https://tinyurl.com/3auzd8pd>

ANNEX 2 - The Theoretical Foundations of AugMENTOR: The enriched Pedagogical Triangle with Digital and Emerging Technologies

The **didactical or pedagogical triangle** (Houssaye, 2014) is a fundamental theoretical concept employed in Learning Sciences to elucidate the dynamic interplay among three pivotal elements within the teaching and learning process (refer to Figure 1). These elements encompass the *teacher*, the *learner*, and the *content (or knowledge)*. At its core, the pedagogical triangle underscores the criticality of interactions among these elements for fostering effective learning. The teacher assumes the responsibility of transmitting content, employing teaching methodologies tailored to the learner's needs. Concurrently, the learner actively engages in the learning process, assimilating or constructing the content imparted by the teacher and connecting it with their existing knowledge and experiences. Likewise, the content must be structured in a manner that is well-organised and meaningful to the learner. In essence, the pedagogical triangle accentuates the significance of the dynamic interrelationship among the teacher, the learner, and the knowledge (content) within the teaching and learning milieu.

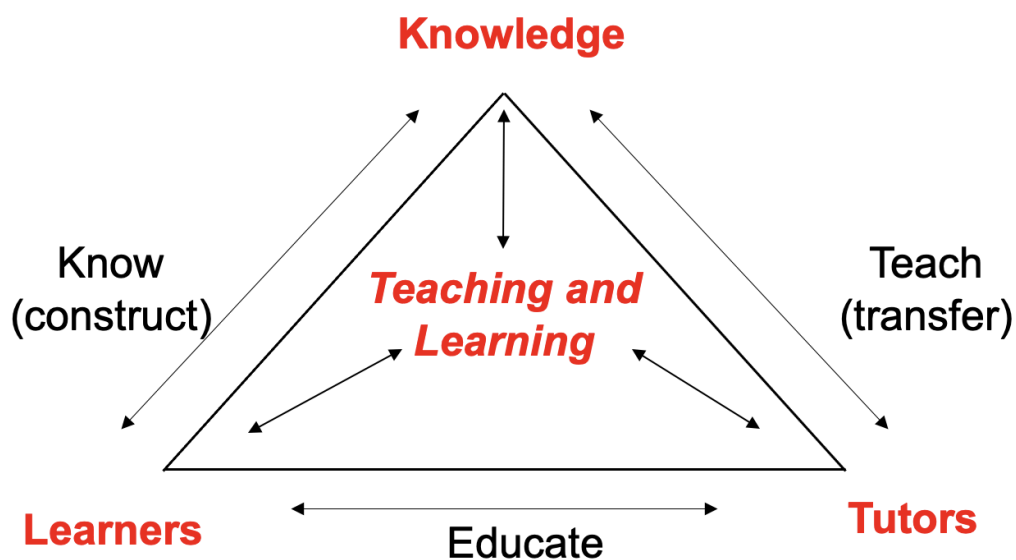


Figure 1. The Pedagogical Triangle

Incorporating technology into the pedagogical triangle (refer to Figure 2) has the potential to enhance the learning process by introducing new opportunities and broadening the scope of how content is delivered, learners are involved, and educators instruct (Komis, 2019). Through the seamless integration of technology into the pedagogical triangle,

educators can establish dynamic, interactive, and adaptable learning environments that cater more effectively to learners' requirements and foster their engagement throughout the process. Of particular significance is that augmenting the Pedagogical Triangle with Digital Technologies addresses each individual interaction among the vertices of the triangle.

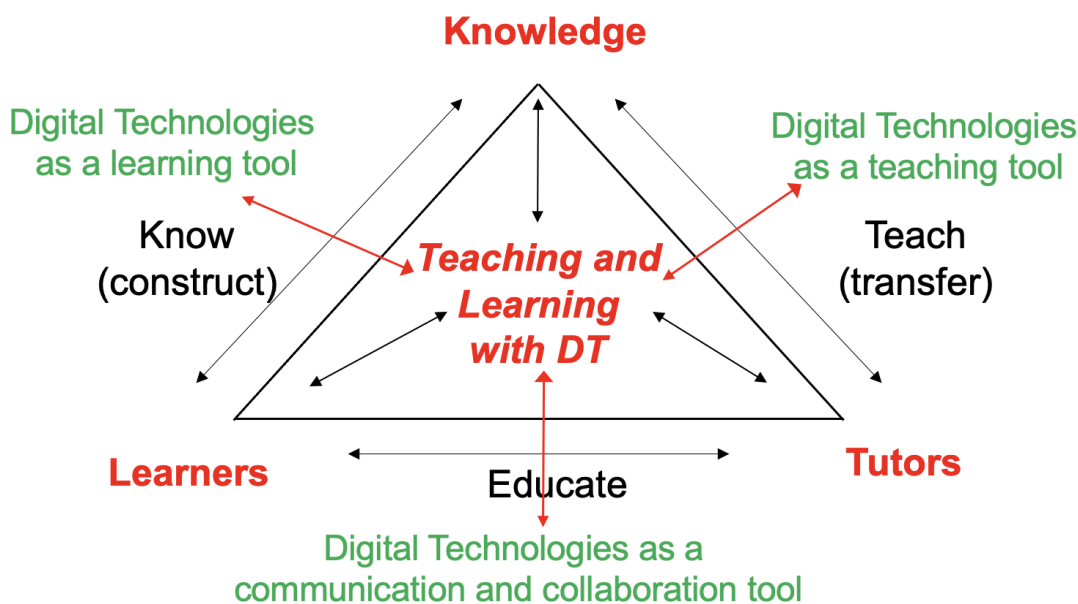


Figure 2. *The enriched Pedagogical Triangle with Digital Technologies*

To begin with, Digital Technologies introduce a qualitatively distinct means of mediating the interaction between learners and knowledge content. In this context, technologies function as cognitive tools, bolstering and augmenting learners' cognitive capabilities. For instance, simulation software in the realm of science empowers learners to formulate hypotheses about models representing the physical world, anticipate their behaviour, and potentially grasp the underlying principles and laws governing them. Similarly, an educational programming language, which not only executes code instructions but also displays the values of the computer's memory and their alterations during execution, facilitates a deeper comprehension of the computer system as a conceptual apparatus.

Furthermore, Digital Technologies, owing to their multimedia and interactive features, serve as potent instructional aids for educators to plan their teaching interventions. These tools enable educators to utilise an array of materials and representations, interconnected in a manner that facilitates the organisation of straightforward assessments and the monitoring of learners' learning progress.

Lastly, Digital Technologies offer suitable computing environments that facilitate communication and collaboration, both within the classroom setting and predominantly beyond it. They extend the physical space of the school through avenues such as virtual classrooms for distance learning interventions when physical presence is unfeasible, as well as broaden the scope of educational time through asynchronous activities on educational platforms. These platforms afford each student optimal management of their study and work time.

The Pedagogical Triangle, enriched with Digital Technologies, constitutes a comprehensive theoretical framework asserting that technologies, contingent upon their affordances, integrate into all relationships that unfold between the vertices of the Triangle: student - content (school knowledge), teacher - content (school knowledge), and teacher - learners. Specific technologies either support or substitute the teacher in the educational process, primarily serving as behavioural technological environments utilised for the transmission or assessment of knowledge. Conversely, other technologies function as cognitive tools, bolstering or even enhancing learners' cognitive capacities for deeper comprehension and the construction of new knowledge. These predominantly encompass constructionist-type technological environments, such as simulations, modelling, virtual laboratories, and educational robots, among others.

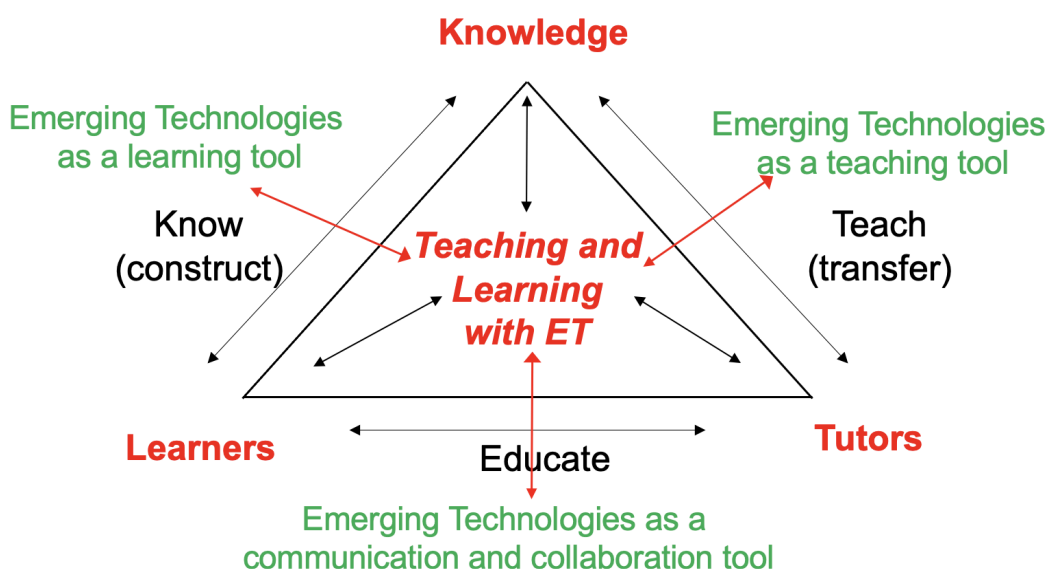


Figure 3. The enriched Pedagogical Triangle with Emerging Technologies

Emerging Technologies such as AI and the Web 2.0 introduce new affordances for enhancing the Pedagogical Triangle (refer to Figure 3). Tailored technologies grounded in cognitive learning theories, like those derived from Generative AI, can assist learners by simulating dialogues and furnishing specialised information across various scientific disciplines. Additionally, the contemporary Internet fosters novel communication and collaboration environments, rooted in the principles of socio-cultural psychology, facilitating novel forms of social interaction and collaborative knowledge construction among learners and educators.

Within the augMENTOR context, it is proposed to augment the Pedagogical Triangle with pertinent Emerging Technologies, including Artificial Intelligence and Learning Management Systems (LMS). Specifically, **the augMENTOR Pedagogical Framework** is based in an enriched Pedagogical Triangle where the relationships among its vertices are facilitated by the suitable tools offered by the augMENTORsolution, particularly the AI functionalities integrated into Learning Management Systems like Moodle (refer to Figure 4). It is evident that the effective utilisation of these tools necessitates adequate training for educators.

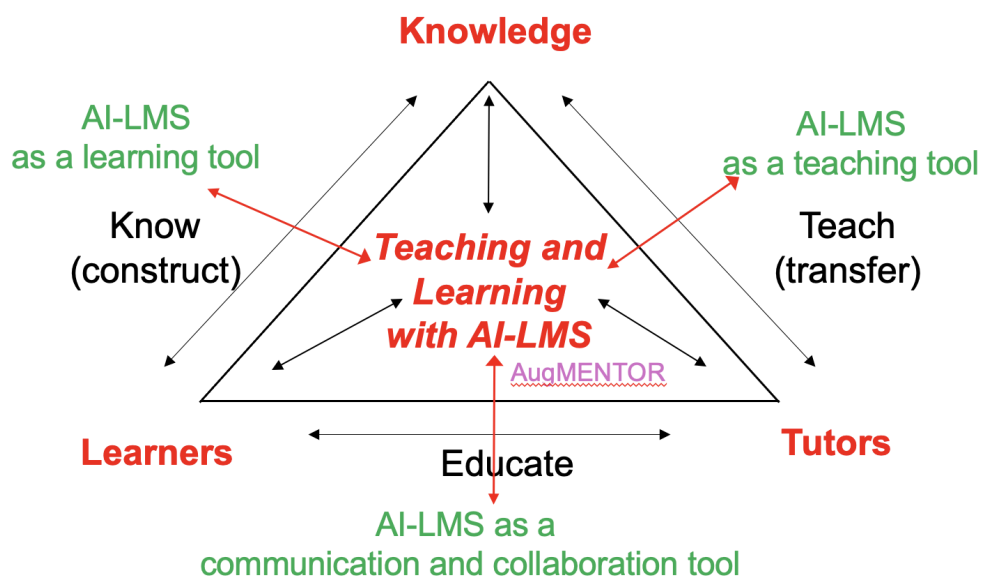


Figure 4. The enriched Pedagogical Triangle in augMENTORsolution

In summary, educators must possess the requisite knowledge and competencies to effectively enhance the Pedagogical Triangle with suitable Technologies, namely those that offer distinct pedagogical potentials. This knowledge encompasses an understanding of how various learning theories inform the design of digital environments aligned with their

overarching principles. For instance, when assistance is required for the teacher in disseminating or evaluating knowledge, attention should be directed towards behavioural-oriented environments. Conversely, for tools aiding learners in knowledge construction, emphasis should be placed on epistemic-oriented environments. Lastly, for tools fostering communication and collaboration, collaborative online environments are sought after. However, this foundational knowledge is insufficient for delineating methods of integrating Digital Technologies into everyday educational practices, nor does it pertain to specific subject areas. Hence, a more analytical theoretical framework is needed, one that establishes connections among content (knowledge), available technologies, and pedagogical methodologies. This theoretical framework is encapsulated within the concept of Technological Pedagogical Content Knowledge (TPACK).

ANNEX 3 - The Theoretical Foundations of AugMENTOR: Technological Pedagogical Content Knowledge in the augMENTOR Pedagogical Framework

Technological Pedagogical Content Knowledge (TPACK), proposed by Mishra & Koehler as a theoretical framework that describes the set of knowledge and skills that educators need to effectively integrate Digital Technologies into their teaching practice (Mishra & Koehler, 2006). Mishra & Koehler extended Shulman's theoretical framework (Shulman, 1986) on Pedagogical Content Knowledge, i.e., individual Teaching Knowledge about a subject matter.

Technological Pedagogical Content Knowledge (TPACK) attempts to identify the nature of the knowledge required by educators to integrate technology into their teaching, while addressing the complex, multifaceted and established nature of educators' knowledge (tpack.org). The TPACK framework, constitutes one of the most well-known frameworks for representing educators' knowledge and competencies about integrating technologies in education and consists of seven components (Figure 1): The three main components, Technological, Pedagogical and Content Knowledge, their three sub-combinations (Technological Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge), and finally, their combination, i.e., Technological Pedagogical Content Knowledge.

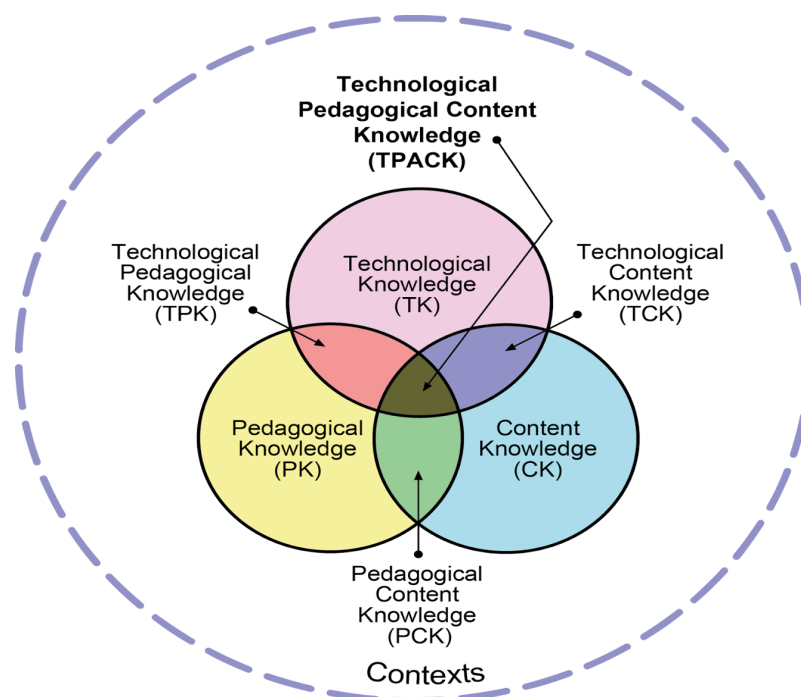


Figure 1. Technological Pedagogical Content Knowledge - TPACK

1. Technological Knowledge (TK): refers to knowledge about the tools, techniques and technologies available for teaching and learning. It includes an understanding of how to use various technological tools such as computers, software applications, the Internet, interactive whiteboards, multimedia resources, distance learning platforms, etc.
2. Pedagogical Knowledge (PK): pedagogical knowledge is knowledge about the general processes of teaching and learning. It includes an understanding of educational theories, learning theories, the pedagogical process, general teaching strategies, basic principles of teaching and learning planning, classroom management techniques, methods of assessment and student achievement, and how to meet different learning needs.

Technological Knowledge and Pedagogical Knowledge are common knowledge that all educators, regardless of their specialisation, should have. In the **augMENTOR project** these knowledge are briefly specified as follows:

augMENTOR Technological Knowledge

In augMENTOR, Technological Knowledge refers to a) the knowledge of using specific AI tools, such as ChatGPT, Gemini, Copilot and b) the knowledge of using LMS, such as Moodle.

augMENTOR Pedagogical Knowledge

In augMENTOR, Pedagogical Knowledge is not differentiated from the Pedagogical Knowledge described in the basic TPACK model.

0. Content Knowledge (CK): the knowledge that educators use and apply when teaching in specific subject areas. Content knowledge therefore refers to expertise in the subject matter being taught. It involves a deep understanding of the concepts, principles, theories and practices of a particular discipline or content area. It therefore refers to expertise in a subject area (Computer Science, Mathematics, History, Science, etc.).

augMENTOR Content Knowledge

In augMENTOR, Content Knowledge is related to the individual knowledge and competences targeted by the individual pilots of the project. For example, in the pilot of the University of Patras, the Content Knowledge relates to a second year course entitled "ICT in Education" in the curriculum of the "Department of Educational Sciences and Early Childhood Education".

In addition to these three core components, the TPACK framework emphasises the integration and cross-fertilization of these core knowledge into three sets of specialised knowledge related to:

0. Technological Pedagogical Knowledge (TPK): this is the understanding of how to use technology effectively to facilitate teaching and learning processes. It involves knowledge of which technologies are appropriate for specific pedagogical purposes and how they are used effectively in teaching contexts. It is common knowledge that educators should have and is independent of the subject matter.

augMENTOR Technological Pedagogical Knowledge

In augMENTOR, Technological Pedagogical Knowledge refers to a) the pedagogical knowledge of using specific AI tools, such as ChatGPT, Gemini, Copilot and b) the pedagogical knowledge of using LMS, such as Moodle.

0. Technological Content Knowledge (TCK): this is an understanding of how technology can be used to represent and present content in ways that enhance understanding and learning. It involves knowing how to use technology to access, manipulate and transform content to make it more accessible and meaningful to learners.

augMENTOR Technological Content Knowledge

In augMENTOR the Technological Content Knowledge concerns a) how the AI tools that will be included in the augMENTOR solution can be used to represent and present the course content to the pilots of the project and b) how the LMS can be used to represent and present the course content to the individual pilots of the project.

0. Pedagogical Content Knowledge (PCK): this is the understanding of how to teach specific content using effective pedagogical strategies. It involves knowing how to adapt teaching methods, instructional materials and assessments to meet learners' needs and facilitate their understanding of the content. As a term, Content Knowledge Pedagogy is closely related to the Teaching of a Cognitive Object.

augMENTOR Pedagogical Content Knowledge

In augMENTOR the Pedagogical Content Knowledge is related to the specific didactics related to the individual pilots of the project.

Therefore, Technological Content Knowledge and Pedagogical Content Knowledge are subject-specific knowledge. A teacher of Computer Science at this level must therefore have different knowledge of TCK and PCK content knowledge than a teacher of Mathematics or Language, since this knowledge is interwoven with Computer Science, Mathematics or Language.

Technological **Pedagogical Content Knowledge** (TPACK): represents the intersection of technological knowledge, pedagogical knowledge and content knowledge (Figure 2). It is about understanding how to effectively integrate technology into teaching and learning

practices, taking into account pedagogical goals and content requirements. The TPACK model emphasises the importance of finding a balance between technology, pedagogy and content knowledge to create meaningful learning experiences for learners. Overall, TPACK provides a framework for educators to develop the knowledge and skills necessary to effectively integrate technology into their teaching practice, ultimately improving student learning outcomes.

augMENTOR Technological Pedagogical Content Knowledge

In augMENTOR, TPACK refers to the case of integrating Emerging Technologies (ET) into teaching and learning processes and is represented as T_{ET} PACK. In particular, this framework consists of three distinct models:

A. T_{AI} PACK (Figure 2): it is about understanding how to effectively integrate AI into teaching and learning practices, taking into account pedagogical goals and content requirements.

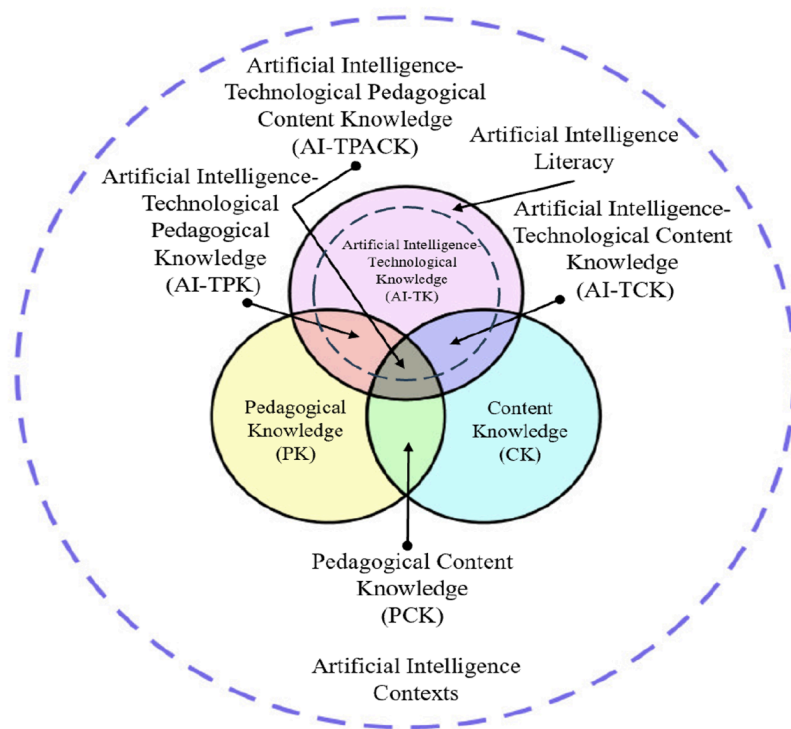


Figure 2. Artificial Intelligence - TPACKAI

B. T_{LMS} PACK: It is about understanding how to effectively integrate LMSs into teaching and learning practices, taking into account pedagogical goals and content requirements (Figure 3).

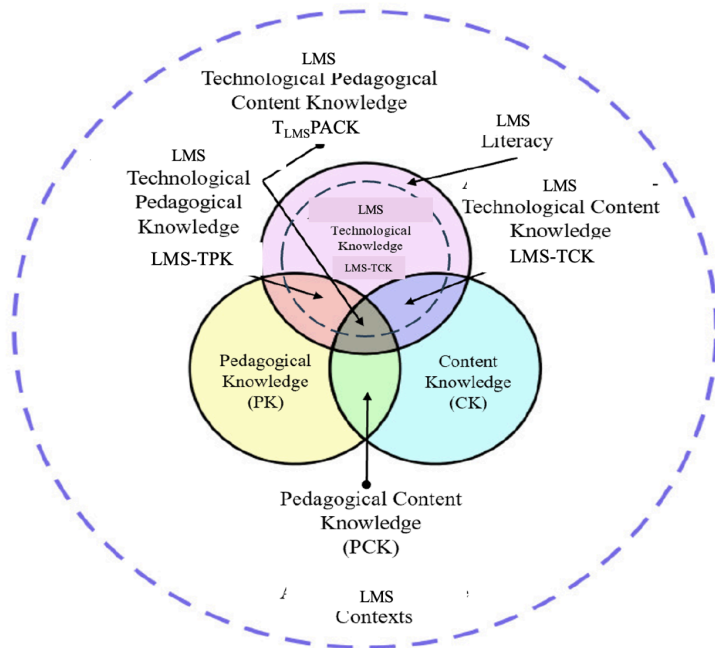


Figure 3. Learning Management Systems TPACK - TPACKLMS

C. T_{AI-LMS} PACK: It is about understanding how to effectively integrate LMSs, incorporating AI tools, into teaching and learning practices, taking into account pedagogical goals and content requirements (Figure 4).

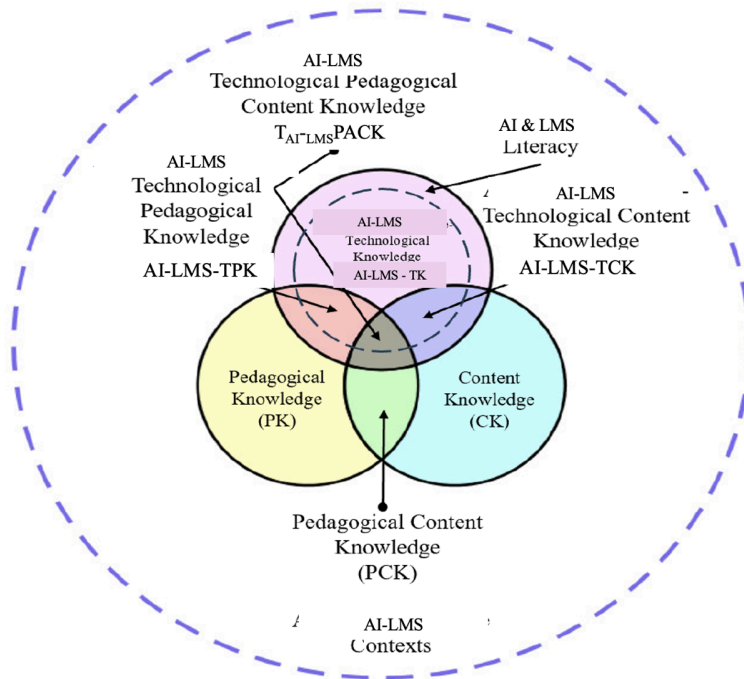


Figure 4. AI & Learning Management Systems TPACK - TPACKAILMS

The educational environment (context)

The **educational** context holds significant importance in educational research and within the framework of Technological Pedagogical Content Knowledge (TPACK). However, it often remains overlooked in research conducted within this field, or its precise implications are not clearly articulated. It is imperative to underscore that within the realm of TPACK, the role of the environment is pivotal, as it acknowledges that the successful integration of technology is profoundly influenced by the specific context in which teaching and learning occur. This environment encompasses a diverse array of factors that define a particular educational setting, including the characteristics of the learners, the curriculum, the learning environment, the available resources, the institutional culture, and broader social, cultural, and political influences. Each augMENTOR Project pilot constitutes a distinct context, and these are comprehensively described in the respective deliverables.

TPACK and Preservice educatorsTeachers

In this section, we illustrate an instance of implementing the TPACK framework within the project, as a questionnaire for the learners. This survey entails transforming the fundamental components of the TPACK framework into a questionnaire that students fill out at the start of the course to document their initial knowledge, skills and attitudes of using ICT in education, in line with the second step of the TESA model. These insights will also be utilised by the system to establish the learners' initial profiles (to create the LM, D3.3).

Educational Context

- I am choosing modules that provide technological knowledge for the educational process as part of my studies.
- Modules involving the use of technology in the educational process will be helpful to my work as an educator.
- I seek to learn more about utilising technology in education by participating in continuous professional development (e.g., attending training courses and seminars).
- Modules of technology in education will support me as an educator.

Content Knowledge - CK

- I have sufficient knowledge of the subject "Language/Literacy".
- I have sufficient knowledge of the subject "Mathematics".
- I have sufficient knowledge of the subject "Science-Physics".
- I have sufficient knowledge of the subject "Arts".
- I have sufficient knowledge of the subject "Computer Science & Information & Communication Technologies-ICT".
- I have sufficient knowledge to develop a deeper understanding of the curriculum content.

Pedagogical Knowledge - PK

- I can design activities on learning topics/themes of the curriculum to support learning.
- I can adapt my teaching methods to meet learners' learning profiles.
- I know how to organise/plan teaching and apply pedagogical principles to maintain control in the classroom.
- I know how to lead/guide learners' assignments and discourses during lesson time effectively.
- I know how to create an engaging learning environment to motivate learners.
- I know how to assess learners' learning.

Technological Knowledge - TK

- I have the skills to use various computer systems and digital environments effectively.
- I can easily use various technological tools (e.g., printer, digital camera, scanner, projector, interactive whiteboard, etc.).
- I can easily use various general-purpose applications (such as drawing, word processing, presentation software, etc.).
- I can easily use various Internet & Web 2.0 applications and services (e-mail, information search, blogs, wikis, forums, social media, etc.).
- I can easily use platforms for distance learning (such as virtual classrooms (e.g., Webex or Zoom) or asynchronous distance learning systems (e.g., e-me, e-Class, Moodle)).
- I can solve simple technical issues/problems for computer systems and software (basic computer settings, software installation and removal, etc.).

Pedagogical Content Knowledge - PCK

- I have sufficient knowledge to teach the curriculum content.
- I know how to plan and support cross-curricular activities and projects focused on the curriculum content.
- I know the cognitive difficulties that learners have in basic learning areas and concepts of the curriculum.
- I can help learners understand the basic concepts of the curriculum in many ways.
- I know how to choose effective teaching approaches to guide learners' thinking and learning in the classroom.
- I know how to deal with the frequently occurring misconceptions that learners have regarding the content of the curriculum.

Technological Pedagogical Knowledge - TPK

- I have the skills to select appropriate ICT tools that enhance learners' learning outcomes.
- I have the skills to select appropriate ICT tools that enhance current pedagogical strategies.
- I know how to support learners to work together utilising ICT in their learning process.
- I know how to support learners in using ICT appropriately to learn.
- I know how to utilise appropriate digital learning environments to assess learners.
- I know how to integrate specific ICT tools in planning teaching for cross-curricular activities.

Technological Content Knowledge - TCK

- I know appropriate digital tools for the curriculum content.
- I can use digital tools developed to follow the curriculum content.
- I know appropriate digital tools for presenting learning concepts and topics that are difficult to represent by other means (e.g., water cycle, day-night, etc.).
- I know digital tools that can enhance learners' conceptual understanding/learning.
- I know a variety of digital tools that are appropriate for teaching specific subjects - learning concepts of the curriculum.
- I can choose appropriate digital tools that enhance teaching.

Technological Pedagogical Content Knowledge - TPCK

- I have the skills to implement cross-curricular activities utilising ICT tools appropriate to each curriculum subject knowledge.
- I have the skills to design and implement activities on curriculum subject knowledge utilising Web 2.0 tools (e.g., blogs, wikis, WebQuest).
- I have the skills to design and implement activities on curriculum subject knowledge utilising digital platforms (e.g., e-me, Moodle, e-Class, etc.).
- I have the skills to integrate teaching strategies that effectively combine content knowledge, ICT tools, and appropriate pedagogical approaches.
- I have the skills to use ICT tools to support the expected learning outcomes fitting the curriculum content.
- I can design inquiry-based activities utilising ICT tools (e.g., simulations, web-based materials) to guide/lead learners' understanding of the subject's content.

ANNEX 4 - The Theoretical Foundations of AugMENTOR: The Cultural and Historical Activity Theory in augMENTOR Pedagogical Framework

Cultural-Historical Activity Theory, also known as Activity Theory, is a theoretical framework initially proposed by Cole (1996) and often referenced in literature by Kaptelinin and Nardi (2006). It provides a foundation for comprehending and analysing the interplay between human cognition (thoughts and emotions) and human behaviour (actions). Originating from the cultural-historical school of Russian psychology established by pioneers like Vygotsky (1978) and Leontiev (1978), this framework posits that human actions are inherently dynamic and must be contextualised to be fully understood. It asserts that individual actions are always situated within a specific context, which serves as the minimum appropriate unit of analysis. This unit is termed an activity.

Activity Theory is regarded not as a standalone theory, but rather as an interdisciplinary framework aimed at investigating how individuals intentionally shape physical and social realities, including their own selves. This process is viewed as an ongoing, culturally and historically embedded endeavour, materially and socially mediated. Key concepts within this theoretical framework encompass collective action and communication, the creation and utilisation of tools, and the significance of community in the construction of meaning. Consequently, within Activity Theory: a) individuals engage in collective action, learning through their actions and communicating within and through these actions; b) individuals construct, employ, and modify various tools to facilitate learning and communication; and c) community plays a central role in the process of meaning-making and interpretation, thus influencing all forms of learning, communication, and action (Engeström, 1993).

The Activity Theory is represented as a system of triangles, where the classical mediating triangle Subject-Tool-Object (top small triangle in figure 1) was enriched with elements of Vygotsky's theory (e.g. mediation by tools, historicity) while expanding to include the **community of** practice to which the subject belongs, the various **rules** that delineate the functioning of the community, and the **division of labour** among community members (Cole, 1996; Cole & Engeström, 1993). This offers a comprehensive depiction of every component within an activity system. This theoretical framework enables the examination, interpretation, and comprehension of the entire context in which the individual operates, broadening the conventional unit of analysis (the individual) to encompass as many contextual elements (tools, object, community, collaboration, etc.) as feasible.

The elements within each activity are structured into activity systems, culminating in a complex model of learning (see figure 1), encompassing subject, object, goal, tools, actions, and functions that impact the outcome, rules, society, and division of labour. To elaborate, the subject of the activity may entail an individual or a collective group of collaborators, thereby forming a community of learners.

The *object*, in fact, is the goal of the activity, thus determining its beginning and end. *Tools* are considered to be both the materials used to form the object, e.g. computers, and the mental processes that take place, such as heuristics, e.g. reasoning, discovery, etc.

An *activity* involves various artefacts, such as instruments, signs, procedures, machines, methods, laws, forms of work organisation. The basic characteristic of all these artefacts is that they have a mediating role: the relationships between the elements of an activity are not direct but mediated.

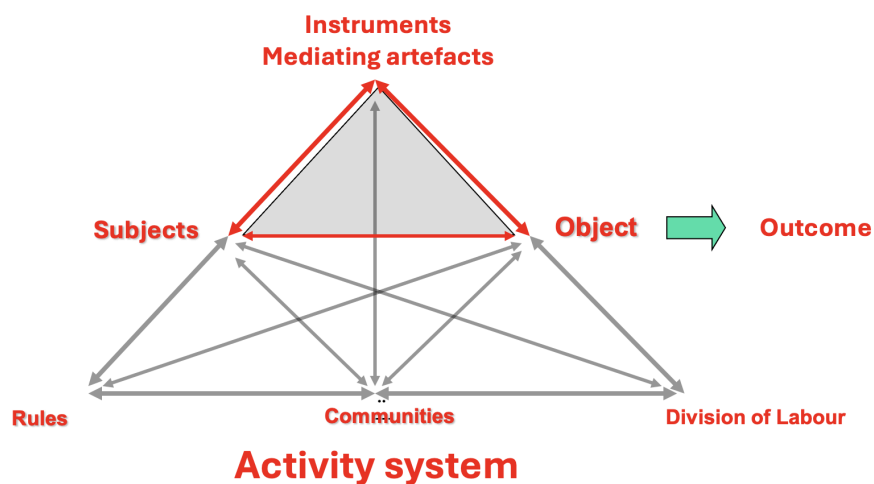


Figure 1. Activity System

In the context of educational technology and teaching science, Activity Theory is used as a guiding theoretical framework to understand how technologies are adopted, adapted and shaped through their use in complex social situations. Learning Technologies, according to Activity Theory, are not a medium that seamlessly transmits knowledge to the user, but rather a cognitive tool that structures and mediates the learning achieved through activity. In other words, Activity Theory considers educational Digital Technologies not as "teaching machines" (as understood by Behaviorism) but as a "support system" for learning through doing. Learning is not only achieved through observation, but primarily through human activity, and Educational Digital Technologies serve to support and structure this activity (DeVane & Squire, 2012).

Most researchers use the Activity Theory framework as an analytical tool to study and describe human activity (DeVane & Squire, 2012). However, certain researchers explore the potential of utilising Activity Theory as a tool for activity design (Jonassen & Roher-Murphy, 1999). They perceive Activity Theory as a suitable framework for examining the requirements, tasks, and anticipated outcomes of an educational endeavour. As a theoretical framework, it serves as a socio-cultural and socio-historical perspective through which designers can analyse systems of human activities, particularly those pertaining to teaching and learning. Moreover, it is evident that the environment in which pedagogical activities unfold plays a catalysing role, influencing both the progression of the activity and its eventual success or failure.

According to Jonassen and & Roher-Murphy (Jonassen & Roher-Murphy, 1999), Activity Theory provides a different lens for analysing learning processes and outcomes for the purpose of instructional design. Instead of concentrating solely on knowledge, Activity Theory directs its focus towards the activities individuals engage in, the tools utilised within these activities, the social and contextual interactions among participants, the objectives and intentions guiding these activities, and the outcomes they yield. Nurturing each of these elements and their dynamic interrelationships is imperative in instructional design, as a richer context and deeper integration of conscious thought processes within that context facilitate the construction of meaning for both the activities and the cognitive processes involved. (Jonassen & Roher-Murphy, 1999).

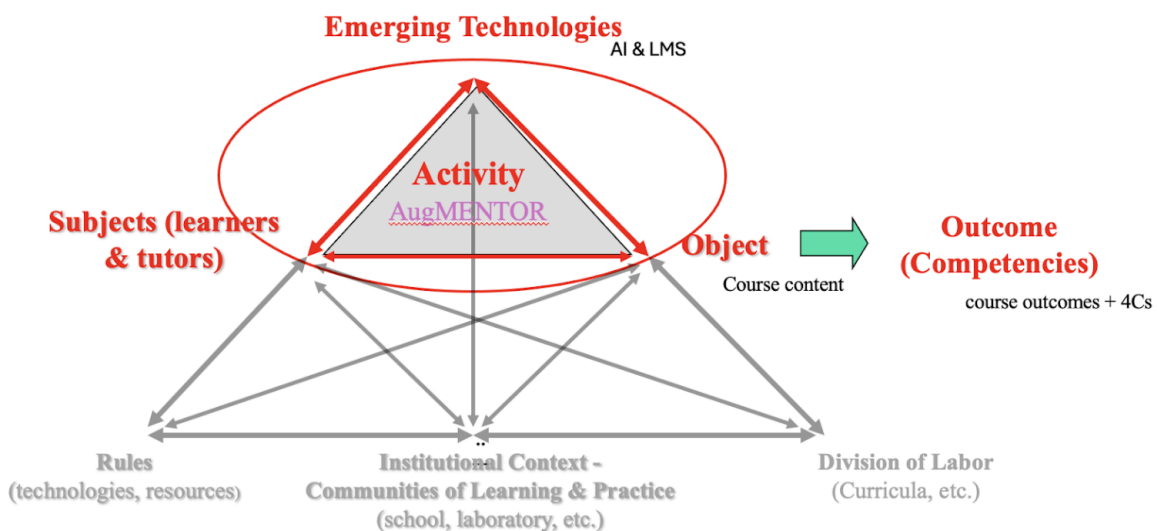


Figure 2. *augMENTOR Activity System*

The Cultural and Historical Activity Theory is used in the augMENTOR Pedagogical Framework both as an analytical (Figure 2) and as a design model, as we will see below.

ANNEX 5 - TESA Framework

The teaching object of the educational scenario

In Phase A, the teaching subject to be studied is defined, including the content of the course and the key components of the scenario. This phase focuses on the specific points of the learning object. Consequently, the title and theme of the scenario, the target class or classes, the relevant knowledge areas, and its alignment with the current curriculum are established. The indicative duration for implementing the scenario in the classroom is also specified.

Once the teaching subject is defined, the primary components of the scenario must be identified. This includes noting the prerequisite knowledge learners should have (what they should know) and their prior (pre-existing) knowledge (what they already know). It is also important to justify briefly why the proposed scenario is suitable for the learners' knowledge level. This phase is exclusively for educators and does not involve working with learners.

To coherently develop this phase, it is essential to answer at least the following questions:

1. What are the individual sections of the teaching scenario on which learners should work to introduce and build the concept or concepts to be studied? Does it cover different aspects and focus on the critical and important points of the learning object (i.e., the concept or concepts that learners need to build)?
2. Does the scenario take into account the **prerequisite knowledge** (the knowledge we assume learners should have based on what they have already been taught)? How is this knowledge valued, and how does the scenario use it organically in the construction of the new knowledge?
3. Does the scenario consider the **prior** (pre-existing) knowledge (i.e., the knowledge that learners have already built up in an appropriate way) that learners have about the concept under study? How is this knowledge valued, and how does the scenario integrate it organically into the construction of the new knowledge?
4. Is the educational scenario appropriate for the student's knowledge level? (i.e., neither too simple nor too complex for the student to implement with possible teacher assistance)?

This phase essentially determines the content (theme, title, subject) of the scenario and its connection to the learners' knowledge. Additionally, in conjunction with Phase B, it briefly describes the main rationale of the scenario: why it was created and what teaching problems it is intended to address.

Furthermore, due to the inclusion of Emerging Technologies in the scenario, it is necessary to define the cognitive prerequisites concerning the software and computational tools to be used.

Learners' representations of the subject matter and possible difficulties in their thinking

In this phase, relevant literature and the teacher's experience are utilised to accurately identify potential difficulties in learners' understanding of the subject matter. Much of the literature documenting learners' challenges in various subjects, along with their prior ideas and representations, is readily available online and can be easily accessed using search engines.

Specifically, it is crucial to identify the prior ideas and representations that learners of the scenario's target age group have regarding the concepts being studied. Simultaneously, possible misconceptions and errors made by learners in the subject are identified, and a detailed list of cognitive difficulties they face is organised. The data from this phase are essential for defining the objectives of the scenario (phase C), developing the teaching material (phase D), and designing the learning activities (phase E). It is clear that in the subsequent phases, it will be necessary to explain how all the identified difficulties in learners' thinking will be addressed didactically.

A thorough development of this phase requires answers to at least the following questions:

1. Does the educational scenario take into account learners' prior ideas and representations of the concept under study? If so, how does it build on these representations and propose solutions for transforming them? How are learners' prior ideas and representations detected? By what cognitive and practical processes is their transformation supported?
2. Does the educational scenario address possible misconceptions and mistakes learners might have about the concept under study? If so, how are these misconceptions and errors identified? In what ways does the scenario seek to refute and overcome these misconceptions and errors?
3. Does the scenario consider the cognitive difficulties that learners may have with the concept under study? If so, how are these difficulties identified, and what are the possible ways of overcoming them?

This phase connects the scenario with the findings of science teaching and the teacher's empirical knowledge of the cognitive problems that learners face regarding the concepts to be studied.

Purpose, objectives and learning outcomes of the educational scenario

In this phase, the **purpose** and the learning outcomes or learning objectives of the educational scenario are identified. In the remainder of the deliverable, the concepts of learning objective and learning outcome are considered to be identical.

The learning outcomes of the educational scenario are defined along two complementary axes: a) subject matter and learning process, and b) the use of Emerging Technologies.

a) The learning outcomes or objectives of the educational scenario are defined in relation to the subject matter to be studied, as outlined by the curriculum. However, it may sometimes be necessary to go beyond the current curriculum. These objectives are also informed by the difficulties learners may have with the subject matter. Based on these expected outcomes, the learning activities of the teaching scenario, the teaching material to be developed, and the use of Emerging Technologies are determined.

A well-formulated learning objective or outcome is the foundation for designing, developing, implementing, and evaluating an educational process. Therefore, the formulation of objectives or outcomes must be explicit and precise, indicating to the teacher the teaching goals and to the learner what they need to know by the end of the educational process. Learning objectives can be:

1. High-level, related to specific competencies, like 4Cs, (alignment with D4.1).
2. Low-level, involving simple knowledge, skills, and attitudes.

Each pedagogical activity (see Phase E) within the educational scenario supports the achievement of one or more objectives. It is necessary to design appropriate activities that cover all the objectives of the scenario. An objective can, and often should, be addressed in multiple activities within the scenario.

b) The objectives related to the use of Emerging Technologies emphasise the need to integrate technology (software, services, tools) into various phases of teaching. These objectives are linked to the specific characteristics of the technology used and the possibilities it provides for achieving the teaching/learning objectives of the scenario. It is important to have objectives that leverage the potential of the technology to introduce new teaching practices. Particular emphasis should be placed on objectives that exploit the added value of Emerging Technologies within the context of the scenario.

The teaching material of the educational scenario

This phase describes in detail the teaching materials required for the implementation of the scenario. The teaching materials include the ready-made teaching materials (e.g. printed materials for learners, maps, software, constructions, etc.) and the additional materials to

be created for the scenario. The emphasis is usually on simple everyday materials (ready-made materials or simple constructions), which can be easily found or created by educators.

The worksheets are part of the teaching material. It is also possible to use appropriate educational software, if available. In this case, the necessary software files and how to use them are described (if required by the scenario, as is usually the case since the use of digital technology is self-evident at this stage).

Finally, the required logistical infrastructure, the visual aids, the instruments and other general materials (e.g. computers, tables, projection equipment, etc.) and the way they are used in the context of the scenario are specified. The scenario should therefore provide for how the teaching materials (worksheets, student book or notebook, educational software, etc.) will be used by the learners.

As already emphasised, the teaching material closely supports individual implementation activities, which will be carried out in the classroom. The broad forms that these activities take are described below.

The activities for the implementation of the educational scenario in the classroom

This phase is the most critical in designing the educational scenario, as it details all the necessary procedures for educators and learners in the classroom. During this phase, the actions of both the teacher and the learners are predetermined to achieve the scenario's objectives, highlighting the importance and necessity of integrating technologies into the teaching and learning process. The specifics of this phase are discussed in the next section.

To develop this phase, it is essential to identify the theoretical and methodological approach of the scenario (learning theories and teaching situations) as well as the teaching approaches and strategies used in relation to Emerging Technologies and other teaching materials.

Each educational scenario is implemented through a series of in-class activities (Figure 1). The scenario activities, usually proposed to learners as e-sheets, are designed to achieve the scenario's objectives. These activities are divided into at least five categories:

1. Psychological and cognitive preparation activities to assess existing knowledge and detect representations and cognitive difficulties.
2. Subject teaching activities that introduce new knowledge.
3. Activities to consolidate the subject matter, helping learners understand and assimilate new knowledge.
4. Subject evaluation activities.
5. Metacognitive activities.

The sequence of these activities follows a standard structure of lesson planning, independent of the potential use of technology. It is crucial to identify the specific activities where a computing environment will be used and to highlight its comparative advantages over traditional teaching techniques.

Technology – augmented e-Activities (in situ & online)

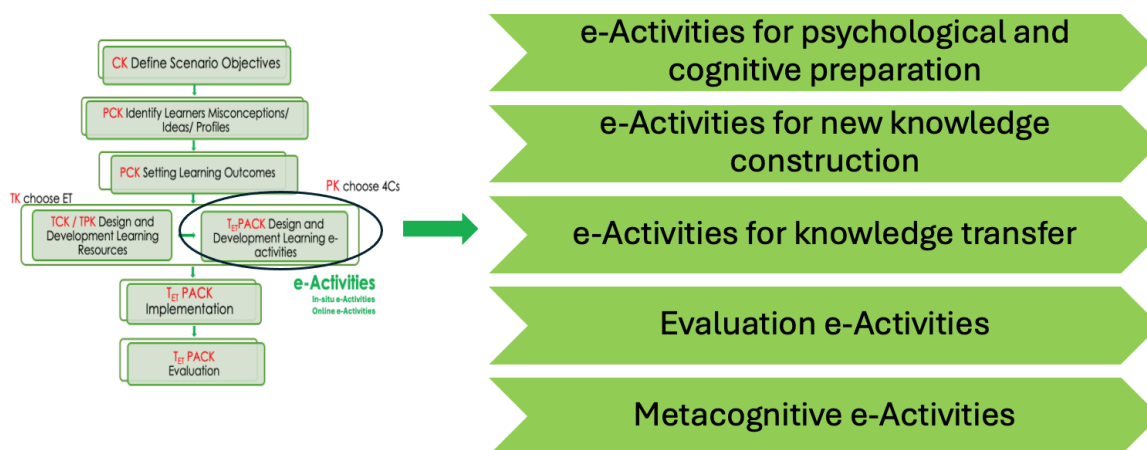


Figure 1. The pedagogical activities of the educational scenario

The activities within the scenario significantly influence the format and content of the e-sheets provided to learners for classroom implementation. Each activity employs one or more teaching strategies or techniques. In the existing literature, the term "teaching technique" is often used interchangeably with "learning strategy." For consistency, we will use the term "learning strategy," referring to a technique based on principles of pedagogical or learning theory aimed at achieving a learning outcome. A more detailed description of these activities is provided in the following section.

The Evaluation of the educational scenario

Evaluation of the educational scenario primarily focuses on the learners' learning progression and the effectiveness of the scenario itself. A comprehensive educational scenario includes specific learning activities designed for student assessment. These activities are integral to the scenario and serve to evaluate the pedagogical effectiveness of preceding activities, particularly teaching and consolidation tasks. They often provide learners with additional opportunities to address specific cognitive needs.

Scenario evaluation typically takes two forms:

- a) Formative evaluation occurs during the scenario's implementation to address any issues that arise and ensure smooth progress.
- b) Final evaluation assesses the achievement of scenario objectives, the implementation process, the effective use of tools, and other relevant factors. Evaluation is conducted within the framework of Activity Theory.

Technology augmented e-activities (in situ and online)

In this section, the concept of **pedagogical activity** as a key component of an *educational scenario* is presented following the main principles of *PedeMET*. By the term **pedagogical activity** we refer to the product of a partial Design process in a specific teaching subject. It describes a system of Activity (according to the Activity Theory), which includes both the activities of the learners and the consequent activity of the teacher in the context of achieving a learning outcome.

In this context, *pedagogical activity* extends the concept of *learning activity* to include all the actors of the educational act, i.e. educators and learners. For the operational definition of *pedagogical activity* we will draw on and extend Conoly's definition (Conoly, 2013). In particular, a *pedagogical activity* is composed of three main elements:

- (a) the context in which the activity takes place, which includes the subjects (learners and teacher), the subject matter of the activity, its level of difficulty, the expected learning outcomes in case the activity introduces new concepts or procedures, and the wider environment in which the activity takes place,
- (b) the learning and teaching strategies adopted, including the theories and models used,
- (c) the processes to be carried out related to the definition of the types of activities, the techniques used, the tools (digital or other) and resources required, the interaction and roles of the actors involved and the possible evaluation associated with the learning activity.

Pedagogical activities, in the context of modern Learning Science, constitute appropriate tools, which specialise the activity of the teacher in his/her teaching practice and the activity of the student in his/her learning practice. *Pedagogical activity* is an inherent component of an *educational scenario* that must accompany modern teaching material (textbook or educational software) and when it is a computer environment it has often been created by the educational software development team.

The phase of organising the *pedagogical activities* of the scenario constitutes the most essential phase of the educational scenario, since during this phase all the required procedures concerning the work of educators and learners in the classroom are described.

In fact, it is the description of the *activity* as it is expected to develop in the classroom. As we have already seen, it is the phase in which both the actions of the teacher and the actions of the learners are predetermined in order to achieve the objectives of the scenario, and in the context of this phase the reasons why it is useful or even necessary to integrate digital technologies in the teaching and learning process are essentially highlighted.

Therefore, for the development of this phase, both the theoretical and methodological approach of the scenario (learning theories and teaching situations) and the teaching approaches and strategies followed in relation to the use of Digital Technologies and other teaching materials must be identified.

As discussed in the previous section, each educational scenario is implemented through a set of in-class activities (Figure 14). In the context of AugMENTOR, the scenario activities are usually proposed to learners in the form of e-sheets and are largely concerned with the achievement of the objectives or expected learning outcomes of the scenario.

The pedagogical activities are divided into five different categories and progress in a specific order during the teaching intervention (Figure 2):

a) Learning activities of **psychological and cognitive preparation** to engage learners and facilitate learning, the scenario incorporates various types of activities:

a) Psychological and cognitive preparation activities aim to attract learners' attention, assess existing knowledge, and identify cognitive difficulties. These activities are tailored to learners' cognitive schemas.

b) Learning activities introduce new knowledge and skills through diverse teaching strategies, aiming to develop learners' understanding.

c) Application activities focus on functional understanding and consolidation of new knowledge, fostering the development of high-level competences.

d) Assessment activities, which take various forms such as self-assessment or peer assessment, evaluate student achievements in alignment with the intended learning outcomes. At least one relevant assessment test is devised.

e) Metacognitive activities involve synthesising acquired knowledge and comparing it with initial ideas and representations.

These activities follow a standard structure of lesson planning, regardless of technology use. Technology is integrated into activities where it adds specific value, offering opportunities beyond traditional educational materials. Typically, cognitive and psychological preparation activities precede others, followed by teaching and application activities.

Assessment activities often follow teaching and application, but in cases where discrete learning outcomes require assessment, assessment activities may precede other teaching activities. Additionally, assessment activities not only evaluate outcomes but also assess the learning process, serving formative purposes.

Identification of activities where computer environments are used is crucial, highlighting their advantages over traditional teaching techniques. These activities shape the content and format of worksheets provided to learners for classroom implementation. Each activity employs one or more learning strategies (Komis, 2019).

Within the framework of augMENTOR, the scenario activities are in digital form and are conducted either in situ, that is, in the classroom synchronously, or online, asynchronously, usually at the time chosen by the learners themselves. As mentioned, the activities are divided into five distinct categories that progress chronologically: first, the cognitive and psychological preparation activities, followed by the teaching and consolidation activities, and finally, the assessment and metacognitive activities.

Cognitive and Psychological Preparation Activities

From a pedagogical perspective, the goal in any educational scenario is to promote learning based on the expected learning outcomes of the scenario. From a psychological perspective, the aim is to achieve conceptual change, meaning the transition of the student from an initial cognitive system to a more advanced one. The cognitive schema or schemas are related to the competencies that need to be developed through the scenario, including knowledge, skills, attitudes, and values.

Thus, knowledge of the learners' initial cognitive schemas is absolutely essential and takes place during the cognitive and psychological preparation activities. These cognitive schemas consist of pre-existing knowledge (valid school knowledge) necessary for building new knowledge, and ideas, perceptions, and representations (knowledge that is not valid from a school perspective).

Additionally, during the cognitive and psychological preparation activities, it is essential to create an appropriate emotional climate and a sense of security for the student, establish a suitable prompt for the lesson, and inform the learners about what will follow, specifically the purpose and goals of the lesson.

Teaching Activities of the Subject Matter

These activities typically occupy the largest part of the educational scenario as they introduce the knowledge to be acquired and conduct most of the activities for acquiring and building new concepts and skills. In combination with the consolidation phase (application of knowledge), they form the stages where pre-existing knowledge is

reinforced, misconceptions and initial ideas of learners are reconstructed, representations are restructured, and the appropriate framework for conceptual change and construction of new knowledge is created.

In these activities, the integration and incorporation of emerging technologies are essential. Therefore, it is necessary to adequately justify the reasons for using an emerging technology for implementing the educational scenario, specifically emphasising its added value and overall advantages for achieving the scenario's purpose and goals.

Teaching activities involve introducing new knowledge and skills that need to be built. These activities are organised using various learning strategies, such as inquiry strategies, collaboration, problem-solving, and project-based learning.

Consolidation Activities of the Subject Matter

Consolidation activities (understanding and assimilating new knowledge and applying it to new situations) usually employ similar learning strategies to those used in the teaching activities. These activities focus on applying the constructed knowledge and aim for higher-level learning outcomes related to competencies rather than simple knowledge and skills.

Assessment Activities of the Subject Matter

Assessment activities are a fundamental and inherent part of pedagogical design, not only because they allow us to evaluate what learners have learned and what they have not learned after completing the scenario, but also because they enable us to assess the overall progress and make necessary adjustments. This approach follows the PeDeMET development guidelines, which outline realistic learning expectations for all learners. Within PeDeMET, which organises student progress based on learning outcomes, the assessment criteria define the knowledge, skills, and practices that learners need to develop and apply in each case. Thus, they serve as specific measures of performance and progress and are reference points for designing (or redesigning) teaching, educational scenarios, and classroom activities, and for evaluating learning outcomes. In other words, assessment concerns both the learning path of the learners and the scenario itself. Therefore, a comprehensive educational scenario includes specific activities related to student assessment, which are an inherent part of the scenario and are used to evaluate the effectiveness of preceding activities (alignment with D4.1).

Metacognitive Activities

Metacognition refers to our knowledge of our cognitive processes (related to perception, attention, memory, thinking, language, and learning), the result of these processes, and

anything related to them. Metacognition involves learning about learning (or being aware of how we learn). Metacognitive activities are an inherent part of the educational scenario and take place both in and outside the classroom. In a metacognitive activity, learners typically compare and contrast the knowledge acquired with their initial ideas and representations, and homework is often suggested.

The design and implementation of metacognitive skills supported by emerging technologies is a subject of PeDeMET. Metacognitive activities usually involve:

- Summarising the lesson and new knowledge acquired
- Comparing initial ideas and representations of learners with the new knowledge acquired in the lesson
- Possible scenario extension
- Discussing the conclusions of the investigation, problem-solving methods, and projects, reflecting and discussing in the classroom, and synthesising knowledge
- Metacognitive assessment
- Self-assessment activities
- Peer assessment activities and peer feedback.

e-Activities preparation

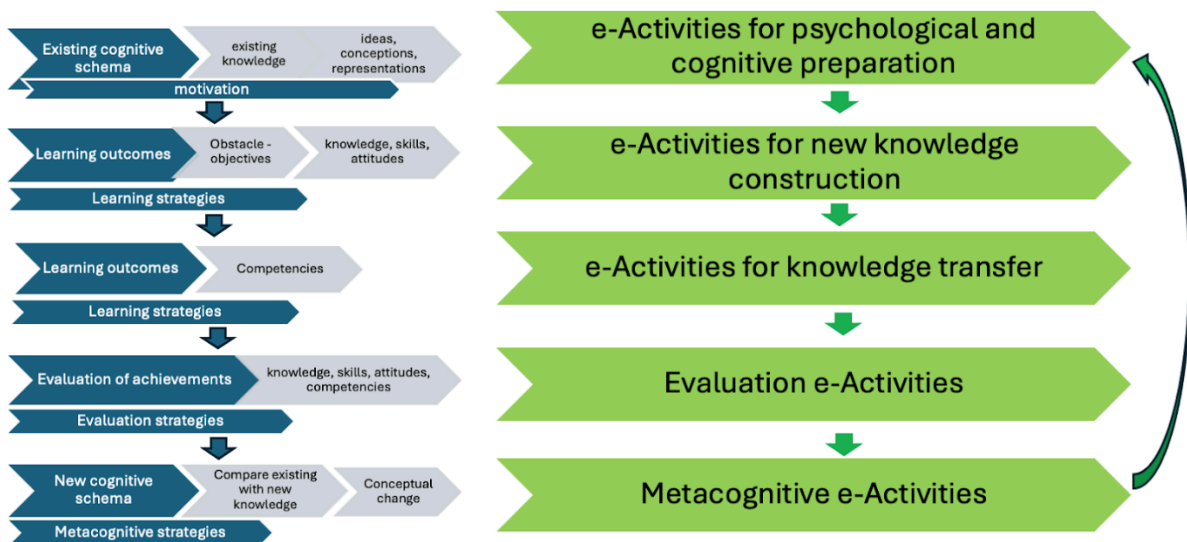


Figure 2. Modelling the e-Activities preparation

ANNEX 6 - The augMENTOR Approach – Alignment with the augMENTOR solution

In our approach (Figure 1), we attempt to gather, interpret, and analyse data to support learners by giving them specific insights and recommendations and evaluate the aforementioned educational scenario. Based on Activity Theory Framework (ATF), each student must complete an activity per week to achieve the object of each week. This goal (objective of the activity) concerns the course curriculum and specifically ICT in Education (to evaluate and integrate concept maps in learning activities for kinder- garten learners) and 21st century skills (creativity and problem solving). Finally, the goal of each activity is being measured according to learners' performance. According to ATF analysis each activity consists of several tasks. The tasks which are available via Moodle can be an assignment, a course material for reading, a quiz, a forum, a discussion or every other activity or resource of Moodle. The tasks are composed by a number of actions that each participant has to do in order to complete them. These actions are different among the tasks and each action has states (values). The number of actions of each task are recorded to a database table which is called *Moodle Data/Logs*. A number of indicators is connected to each task. The indicators are of different types like social and cognitive indicators and creativity indicators. So, for a task that contains a quiz there will be a quiz cognitive indicator, for a forum task there will be a forum cognitive indicator and a forum social indicator, etc. Each indicator will be calculated according to a certain process. Based on these calculation processes, the augMENTOR solution will aid tutors in supporting learners to accomplish the goals of each week.

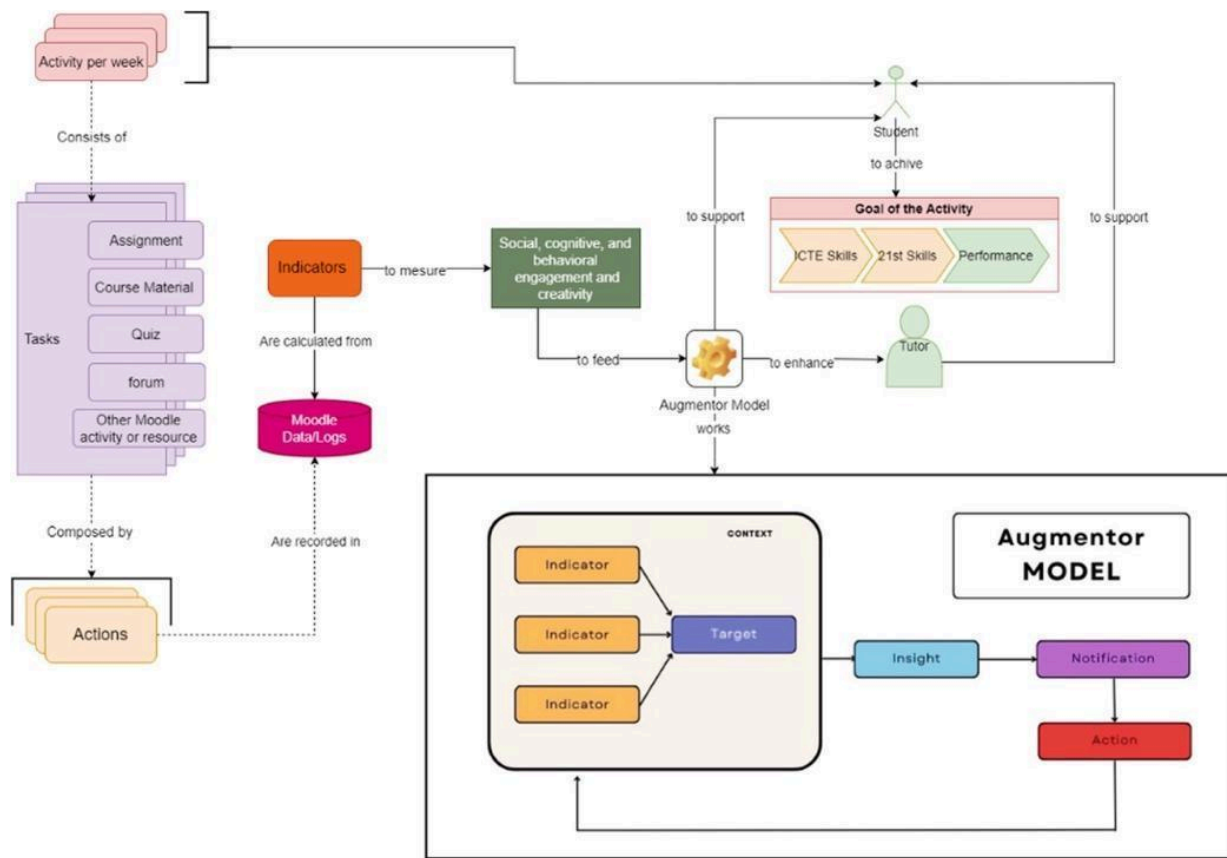


Figure 1. *The augMENTOR approach.*

Data Resources and Engagement Indicators

Both quantitative and qualitative methods will be used to collect the data produced by learners. Quantitative data will be collected through log files (e.g. time devoted on selected tasks etc.) maintained by Moodle (e.g., quiz data, discussion data, assignment data), pre/post surveys (questionnaires to assess digital literacy and Technology, Pedagogy and Content Knowledge, and collect demographic data), digital artefacts created during training, and self-reflection activities (e.g. concept maps). Qualitative data will be collected via interviews with educators/tutors and certain learners who will be selected randomly at the beginning, mid, and end of their participation in a two-hour compulsory workshop session. Also, we plan to use rubrics for self-assessment, observations from the workshops and learning activities in portfolios/wiki/forum/written assignments, which will give the indicators for learners' performance.

Educational resources, such as online eBooks, educational items in digital libraries, dedicated digitised materials, educational scenarios, and dedicated curricula, are also considered. The data will be captured in order to be analysed so as to evaluate users' actions and practices, and all actors' attitudes and performance will be examined in relation to these actions and practices. This data will be presented in a visual format, such

as graphs, to aid learners in better comprehending their progress and assist tutors in providing appropriate guidance for each individual. Using this information, pre-service educators will be provided with customised advice, suggestions for various learning paths, and additional complementary material to enhance their skills.

The problem we face is that there does not exist a valid, commonly accepted, and broadly used framework for measuring the level of engagement of learners in environments like Moodle. One common approach for student's engagement in online environments is to measure different dimensions of engagement by using performance indicators, which are specific metrics that are used to evaluate the level of cognitive, social, and other types of engagement of learners in a course or learning environment. In our case cognitive depth indicators measure the level of student involvement in activities that promote critical thinking and problem-solving. They assess the type of activity provided to the student and the degree to which the student demonstrates cognitive engagement in that activity. Social breadth indicators measure the extent to which learners are given opportunities to interact with one another, build relationships, and engage in collaborative learning. They evaluate the range of communication channels available to learners, such as discussion forums, chat rooms, and group projects. Creativity indicators measure the degree of creative engagement a learner can experience as a socio-cognitive process. Creativity indicators measure a student's ability to think, imagine, and produce original and innovative ideas or solutions to problems. These indicators can include various aspects such as fluency, flexibility, originality, elaboration, risk-taking, imagination and sensitivity to problems. By developing these indicators in our solution, instructors and researchers can gain insights into the level of student engagement and identify areas where improvements can be made to promote deeper learning and a more fulfilling educational experience.

The Moodle platform offers an integrated Learning Analytics tool suitable for building self-learning predictive machine learning models which is supported by a number of predefined indicators for social and cognitive engagement. These indicators are based on the theoretical framework of the Community of Inquiry which defines cognitive presence and social presence as the two primary components of student engagement. However, the models constructed using these pre-established core indicators within the Moodle Analytics API exhibit a level of goodness and predictability that falls below the commonly acceptable standard. This leads to machine learning models with low predictive capabilities, which may cause several false alarms about learners' performance or learners' risk of failure. The reason behind that poor performance of these built-in machine learning models is that the calculation of all core indicators is the same for all supported components (activities and resources of Moodle) and depend on the level of interaction of student with the component (viewed, submitted etc.) and not on the quality or correctness

of the answer given. If we consider a quiz-type indicator, it implies that upon completing all questions, the indicator will receive the maximum value, regardless of whether the answers were incorrect, or the questions were not viewed. This approach to calculation appears illogical for quiz-type indicators, as the indicator value should be closely linked to the success function.

Redesigning and Building New Indicators

The exploitation of indicators for our machine learning solution involves the evaluation of the performance of existing indicators that Moodle offers, and other researchers propose, the identification of their limitations, and the development of new indicators that better capture the relevant data features. The process of redesigning and building new indicators includes:

- Definition of the problem: we will start by exactly defining the problem we are trying to solve and what kind of data we have. Understanding the nature of the data is important as it will inform the choice of indicators.
- Evaluation of the existing indicators: we will review the performance of existing indicators and identify their strengths and limitations; this will help us understand which indicators are most useful and where improvements are needed.
- Identification of new indicators: we will build new indicators that better capture the relevant features of the data; these may be derived by meaningful combinations of existing indicators or be completely new.
- Testing and refinement of indicators: we will evaluate the performance of the new indicators and compare them to the existing ones; we will then refine the indicators based on the results of the evaluation.
- Validation of the indicators: we will validate the indicators on new data to ensure that they generalise well and can be used in practice.

The Educational Scenario Template

A. Educational Scenario Template

Partners Name				
Section	Instruction description	Details - Examples	Description based on the Pilot	Data to be Collected
Name of the Scenario- Pilot	Name the scenario	"Innovative Training Programs for Pre-service educators"		
Brief description	Describe briefly the main idea of the scenario		
Aim of the Scenario	Specify the aim of the Scenario and the target group	Also define the target group/ Audience (e.g. preschool, primary, learners)		
Teaching and Learning Environment	Define of Learning Approach	Traditional Classroom, Blended Learning, E- learning, etc		
Learners Misconceptions / Prior Knowledge- Educational Needs	Learners' ideas and representations, possible difficulties in thinking about the topics and or educational needs			
Learning Outcomes	The teaching objectives of the educational scenario based on your curriculum (in terms of the topic, in terms of the use of	Define the outcomes of the scenario: A. Specific knowledge, skills, attitudes and		

	ICT, in terms of the learning process)	values (competencies) B. 21 st Century skills		
Learning Contents	The teaching material of the educational scenario and the required logistical infrastructure	Presentations, Video, Documentaries, Concept Maps....		
Learning Activities	Planning the learning process by designing appropriate classroom activities	Course on weekly Basis, MOOC... Forum, Wikis, Quiz....		
Teaching approaches and strategies	Define the teaching approaches and give a brief description	Problem Based learning, Inquiry learning, Collaborative learning, Practice based		
Problems to be solved or supported by augMENTOR solution	Address problems to be solved or supported by augMENTOR solution	Identification of groups Recommendations to the learners/ educators Facilitation of assessment Real- time support		
Type of Learning Setting	Indicate the types of the learning settings	Workshops, Lecture, Self-directed Learning, Practice based...		
Roles	Describe the roles of all the participants involved in the course	Teacher, Lecturer, Assistant, Tutor, Learner.....		

Technology – Based Platform	LMS, Cloud Based Platform	Moodle....		
Use of ICT	Educational Software, AI technologies, Apps, etc.	ChatGpt, SurveyMonkey....		
Evaluation	Formative Assessment – Summative Assessment	Tools: Rubrics, Assignment, Interviews, Notes.... Individually/ Group- Assessment		
Notes				

B. Description of the learning activities for implementing the educational scenario:

Based on Activity Theory Framework (ATF), each learner must complete an activity per week to achieve the objective of each week. This goal (objective of the activity) concerns the course curriculum (i.e. specifically ICT in Education) and 21st century skills (creativity and problem solving). Finally, the goal of each activity is being measured according to learners' performance. According to ATF analysis each activity consists of several tasks. The tasks which are available via Moodle can be an assignment, a course material for reading, a quiz, a forum, a discussion or every other activity or resource of Moodle. The tasks are composed by a number of actions that each participant has to do in order to complete them.

These actions are different among the tasks and each action has states (values). The number of actions of each task are recorded to a database table which is called *Moodle Data/Logs*. A number of indicators is connected to each task. The indicators are of different types like social and cognitive indicators and creativity indicators. So, for a task that contains a quiz there will be a quiz cognitive indicator, for a forum task there will be a forum cognitive indicator and a forum social indicator, etc. Each indicator will be calculated according to a certain process.

This phase constitutes the most essential phase of the design of the educational scenario, since it is during this phase that all the required procedures concerning all participants in the course are described. It is the phase during which both the actions of the tutor and the actions of the learners are predetermined in order to achieve the objectives/goals of the scenario, while the reasons why it is useful or even necessary to integrate technologies in the teaching and learning process are essentially highlighted.

Therefore, in order to develop this phase, both the theoretical and methodological approach to the scenario (learning theories and teaching situations) and the teaching approaches and strategies followed in relation to the use of ICT and other teaching materials need to be identified.

In this context, each educational scenario is implemented through a set of activities. The scenario activities are usually proposed to learners in the form of tasks and are largely concerned with achieving the objectives of the scenario. These activities are divided into at least five different categories:

- a) Introduction - psychological and cognitive preparation activities to assess existing knowledge and identify representations and cognitive difficulties
- b) activities for teaching the subject matter that introduce new knowledge
- c) Complementary activities (i.e. proposals for the study of supplementary material)

a) Introduction - psychological and cognitive preparation activities to assess existing knowledge and identify representations and cognitive difficulties

The initial activities of the educational scenario are related to psychological and cognitive preparation, the formation of motivation for the lesson, the information about the purpose and objectives of the lesson as well as the assessment of existing knowledge, the detection of cognitive difficulties and the learners' representations. It is also appropriate to make appropriate reference to the technologies that will be used in the implementation of the scenario in the classroom.

The activities related to the assessment of prior and existing knowledge as well as the activities related to the detection of learners' cognitive difficulties related to ideas, perceptions and representations can be carried out using appropriate teaching strategies such as question and answer activities (asking for a definition, asking a question), brainstorming, creating or annotating drawings and conceptual mapping. In this context, the following steps are usually followed:

- Establishing an appropriate emotional and safety climate for the learner (Formulate an introductory commentary to use ... Frame with appropriate commentary the possible use of a computing environment ...)
- Provide an appropriate stimulus for the lesson (Formulate an introductory comment to arouse the learner's interest in the lesson)
- Inform learners about what will follow (In very few words)
- Informing the learners about the purpose and objectives of the lesson (After the end of the lesson you should be able to....)
- Investigate prior and prerequisite knowledge (What do you know about...)

- Explore ideas, perceptions, representations (What have you heard or read about... What do you think about...)

Activities related to the assessment of prerequisite and prior knowledge as well as activities to detect learners' cognitive difficulties related to ideas, perceptions and representations can be carried out using appropriate teaching strategies such as question and answer activities (e.g. e.g. asking for a definition, asking a question), brainstorming, creating or annotating drawings and conceptual mapping (see

b) Teaching activities of the subject matter

This phase usually occupies the largest part of the educational scenario since it is in the context of this phase that the knowledge to be acquired is introduced and most of the activities of acquisition and building of new concepts are carried out. This is the phase where pre-existing knowledge is reinforced, where learners' misconceptions and initial ideas are reconstructed, where representations are reconstructed and where the appropriate framework for conceptual change and the construction of new knowledge is created.

This phase requires organic integration and integration of the computational environment(s) used.

The activities required in this phase should address at least the following questions:

1. What are the goals of the proposed activity? In which tasks this activity is going to be completed?
2. What type of teaching strategies does the educational scenario use? What are the actions required from the teacher to implement them? Which of the proposed teaching strategies are involved and how is the computer environment used? Why is it useful or necessary to include the computing environment in these teaching strategies?
3. What type of teaching situations does the instructional scenario favour (such as individual or collaborative, closed or open, scalable)? What are the actions required from the tutor to implement them? In which of the proposed teaching situations is the computing environment used involved and how? Why is it useful or necessary?
4. What type of teaching aids- material does the scenario suggest? What are the actions required from the tutor to implement them? How does the process evolve with the teacher's interventions? In which of the proposed teaching aids is the computer environment required and why? Why is it useful or necessary to include the computing environment in these teaching aids?
5. Does it suggest cognitive type conflicts and what is the role of the teacher and the instructional materials or software used in this process? In what cases and in what ways can the computing environment foster cognitive-type conflicts in learners?

6. How are the interactions between learners, the material used and the teacher organised? How is meaningful collaboration between learners and teacher fostered? Does the computing environment support this process and if so how?

7. Which are the assessment strategies that are integrated (rubrics, text analysis...)? How do these strategies, in what means these strategies evaluate the goals of the activity and 21st century skills?

(c) Complementary activities (i.e. proposals for the study of supplementary material)

In this phase the description of the supplementary material and all the actions required to be included in the course in order for it to be complete and provide learners with all the material they need to avoid the risk of disorientation of the learners.