Artificial Intelligence in the Implementation of Didactic Principles in a Novel Mobility Platform: The Case of the eMediator Project

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Abstract. Artificial Intelligence (AI) can support educational platforms in many ways: personalizing a learning process, supporting assessment and content organization, and assisting students. Its implementation in dedicated environments, such as the educational mobility platform, can help designers create a versatile environment that meets the requirements of learners and teachers. The article aims to identify how Artificial Intelligence can aid the educational processes ruled by eight didactic principles. The principles govern the instructional design process and optimize the learning process. The study involves use cases for each didactic principle and their qualitative analysis to find how AI could aid in achieving the didactic principles. The results indicate that AI can facilitate the realization of didactic principles in educational endeavors in three key aspects: personalized learning content, individual assessment, and providing meaningful interactions. Moreover, algorithms can verify their realization in a faster and more accurate manner in comparison to human-driven educational processes.

Keywords: Artificial Intelligence, Didactic Principles, eMediator Project.

1 Introduction

As disruptive technologies have evolved over the past two decades, the human environment has undergone profound technological changes. Artificial Intelligence is an example of this: it has become increasingly prevalent in our daily lives, including education. As expected to be one of the pillars of the upcoming technological revolution, its role in information systems for education and training has proved significant. Taking into account its versatility, AI could also support educational mobility processes. It can be done by developing an AI-based platform within the Erasmus+ project called Ecosystem for European Education Mobility as a Service: Model with Portal Demo (abbreviated as eMediator) [1]. The project creates foundations for the prototype of a mobility platform that can be used for educational and business purposes. Four areas, such as pedagogy, technology, organization, and competence acquisition, are elaborated to create a dedicated, optimal environment for educational mobility. In this article, implementing AI to realize didactic principles will contribute to both competence acquisition

and pedagogy areas. It is assumed that AI can foster the realization of a didactic process through AI-based activities designed according to specific didactic principles. This article examines how Artificial Intelligence can be used to implement didactic principles in educational activities that are part of the eMediator project. The main research question is qualitative: How can AI aid the educational process ruled by eight didactic principles? Eight use cases (each for one didactic principle) were applied and analyzed to answer a research question in the study. Use cases are defined as interactions between one or more actors and the system to be developed [2]. In short, they described the requirements actors want the system to perform [3]. Through the qualitative analysis of the proposed use cases, we identify key aspects in which we recognize AI's role in realizing didactic principles.

2 Artificial Intelligence in Educational Process

Recent advances in AI, deep learning, natural language understanding, and machine vision have led to new systems oriented toward human cooperation [4]. Systems such AlphaStar, AlphaGo [5], OpenAI Five or IBM Watson proved that in many cases, human-machine interaction should not be considered as competition and substitution but rather as an area of potential collaboration where the computational intelligence of a machine can enhance human talent. One of the ways of collaboration is an educational process. Regarding this particular area, there are specific areas of use of Artificial Intelligence: techniques, machine learning, educational data mining knowledge tracking, learning analytics, learner modelling, environments intelligent tutoring systems, learning management systems, intelligent agents, multi-agent, pedagogical agents, visualization of learners' data, open learner models, learning analytics dashboards [6]. Software for education can be customized to meet the needs of students. According to Klasnja-Milicevic and Ivanovic, AI can help improve critical parts of courses, providing helpful feedback to students and educators. Moreover, automating basic educational operations can help instructors and administrators with administrative tasks. Also, AI can automate basic educational tasks, like grading, changing data findings and engagement, and personalizing content for the student. Finally, schools can use AI-powered data to locate, teach, and assist students [7]. Such various functions indicate that AI is a powerful tool that can be implemented in education. There are specific requirements for using AI in online learning environments regarding its wide use. They include:

1) utilizing various data mining techniques, collecting data about learners,

2) identifying their progress, activities, and needs, and providing learners with the possibility of viewing and analyzing their progress through means of an open learner model (there is a possibility of creating and building a learning model), with learning analytics,

3) measuring, collecting, analyzing, and reporting student data,

4) offering an adaptive assessment based on the exam taker's previous performance,
5) implementing a fully personalized approach to learning (a customized approach) based on each learner's strengths, needs, skills, and interests [6].

Having the characteristics of AI in the educational process could make it possible to apply it in the design of learning activities that fulfil didactic principles. Challenges arise in implementing intelligent technologies, encompassing strategy, organizational maturity, governance, and infrastructure. A strategy is a general plan of action for achieving a specific long-term goal according to a schedule agreed upon with all stakeholders. Organizational maturity refers to employees, processes, and technology readiness and capability for adopting artificial intelligence. Since machines learn based on data, data governance is an essential component of implementing and maintaining AI. Regarding infrastructure issues, compatibility and integration are particularly important [8].

3 Didactic Principles

Didactic principles are general standards of didactic action, enabling the implementation of education goals. In addition, the principles of education are fundamental didactic regularities that participate in all educational processes (teaching and learning) and, at the same time, help the teacher understand these processes and plan them. The education principles are formulated based on scientific knowledge but also consider the long-term educational practice of past generations of teachers. It is worth noting that the principles of education may vary depending on the country, education system and level of education. The above principles are a general outline that can be modified and adapted to the specific educational situation. The analysis of existing literature yields a compilation of didactic principles, enumerated as follows:

1) *Direct contact with the learning content* (enabling better understanding, assimilation, and application) [9]. This principle requires the learner's polysensory contact with the learning content. In other words, if direct contact is impossible, it is learning in direct contact with the learned reality or its substitutes (didactic materials). Thanks to the stimulation of many senses, learning is straightforward, and its effects are durable.

2) *Accessibility* (adaptation of teaching materials, methods, and didactic tools to learners' developmental stages and physical abilities) [10]. This principle means adapting the teaching material, didactic methods, teaching materials and learning environment to learners' physical and mental/intellectual characteristics and capabilities. According to this principle, educators should start with what is known and close to the learners and move on to what is new and distant (abstract), move from what is more accessible to what is more complex, take into account the differences in the development and intellectual potential of learners and not intellectually overwhelm

them. An essential condition for implementing this principle is the excellent knowledge of learners, which is a particular challenge in distance education.

3) *Regularity* (the need to implement the learning and teaching processes in a strictly logical order and refer to both the work of the teacher and learners) [11]. Regularity is fundamental in building human knowledge because the explored world is often not a random collection of various phenomena and chaotic processes but is causally conditioned. This principle consists of the need to organize education in such a way that it considers the logical structure of the content taught. It points to the necessity of constantly referring to the already memorized content, highlighting the most critical issues and their hierarchy.

4) *Conscious and active participation of learners in learning and teaching processes (*refers to the limited dependence of the learner on the teacher; activity is the driving force of action, and awareness of the purpose and task of their action is a crucial condition for achieving positive results) [10]. Awareness of the goals and an active attitude towards learning are necessary conditions for achieving the goals of education. This principle is observed when the learner not only knows the learning goals but also knows how to achieve these goals independently or with the help of an educator and is willing to make an effort in this direction.

5) *The operability of students' knowledge* (the use of acquired knowledge by learners and its use in a conscious and planned way; passive knowledge becomes operational knowledge) [12]. This principle is relatively rarely mentioned in the literature. However, it seems worthy of attention as it focuses on developing practical use of knowledge, skills and competencies acquired in the education process to transform the surrounding reality. The operability of knowledge can be obtained mainly thanks to problematic teaching methods because solving problems "activates" already possessed knowledge in new contexts.

6) *The relationship between theory and practice* (referring to practice and showing the need for a given knowledge makes learners more willing to learn issues that they can then use in practice, and the acquired knowledge is better consolidated [13]. This principle indicates that education should be organized to use the learning outcomes in out-of-school situations.

7) *Forming learning skills* (students organize their know-how to acquire information and use them) [14]. Today, learning concerns all stages of life and takes place not only in educational institutions. Developing learning skills at the school stage allows people to constantly update their knowledge in adulthood, deal with challenges and build attractiveness in the labor market. Learning ability consists of choosing appropriate learning methods for a given situation, adequately assessing one's knowledge, formulating learning goals, organizing one's learning process, effective time management (individually/group), and practical information management (individually/group).

8) *The principle of continuing education* (orientation of education towards individual and social objectives, following the idea of lifelong learning) [14]. Due to the intensive changes of the modern world, schools will not equip students with knowledge, skills and competencies that will be up-to-date and needed throughout their lives. Therefore, lifelong learning is necessary. Implementing this principle is based on the ability to read with comprehension, choose suitable sources of knowledge, select information, remember, generalize and draw conclusions for the future.

It should be stressed that the catalogue of didactic principles is open. Changes related to new environments and tools (ICTs) may stipulate the formulation of new ones. The abovementioned didactic principles apply to different age groups and help organize all educational processes at every stage. In the eMediator project, it will be AI, which will aid the realization of didactic principles.

The following section will present use cases concerning AI's realization of didactic principles. The use cases could be implemented in the platform prototype and tested for relevance.

4 Methodology

The first step in the methodological procedure is formulating use cases using AI to achieve didactic principles. The second step is their qualitative analysis to determine how the AI will aid the achievement of didactic principles. This methodology has limitations related to a subjective approach based on the designer's experience. Moreover, use cases do not represent the system's functionalities since they are user-oriented and verified. Finally, categorizing how AI aid didactic principles fulfilment is burdened with subjectivity in interpretation. This subjectivity is characteristic of the qualitative approach in research [15], which, in some cases, is treated
as an asset, specifically in a situation where individual, dedicated solutions are concerned.

5 Results

This section will cover the two steps of the research procedure: the formulation of use cases and their qualitative analysis.

5.1 Use Cases

The use case development involves four steps: the description of a use case (providing a context), specifications of pre-conditions (need to meet before executing the test case), test steps (what should be done to achieve a result), expected results (after execution of a test case) (Fig.1).

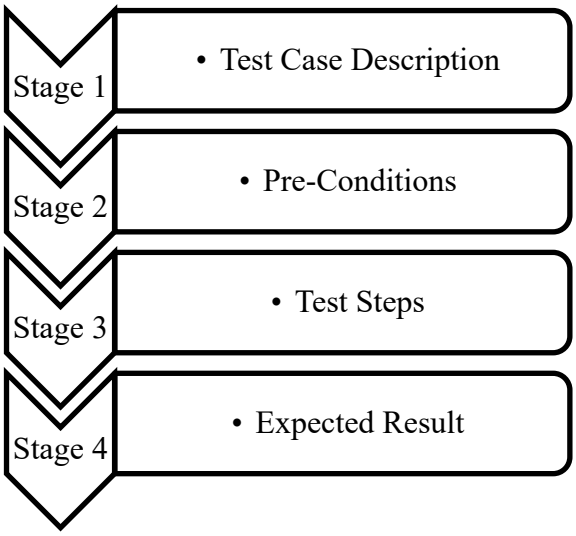

Fig. 1. Steps for the use cases procedure.

First didactic principle: *Direct contact with the learning content*

Step 1 - Test Case Description: To prepare the learning content for an individual, the system uses historical data from a learning process and preferences expressed by a student in a portfolio (available to create on the platform) and from online interactions. Students' preferences can be communicated by "likes and dislikes" concerning specific topics or activities (social media patterns) such as discussions, didactic games, case studies, and multimedia. In this way, the system learns what is appropriate for a learner and what is not. The system serves well-tailored content that is engaging and motivating.
Step 2 - Pre-Conditions: Portfolio and student communication are possible on the platform. Historical data are available for algorithms which match the appropriate content to the user.

Step 3 - Test Steps: AI algorithms are trained to match the content delivered to a learner. The choice can be evaluated by a student (by likes and dislikes, for example).
Step 4 - Expected Result: Students get the content that is prepared according to their learning progress, portfolio information, and preferences.

Second didactic principle: *Accessibility*
Step 1 - Test Case Description: Tests concerning the level of knowledge and learning preferences are conducted to evaluate the student's level. The pills of knowledge are chosen based on the test results.
Step 2 - Pre-Conditions: Data on students' learning preferences and different tasks are the conditions for fulfilling this principle.
Step 3 - Test Steps: Students take a questionnaire concerning their learning preferences before any educational activity. A pretest concerning a specific topic is vital to finding out the information about the learner's level. The gathered data would aid AI in matching the tasks to a student.
Step 4 - Expected Result: Didactic methods, tools, as well as the level of the content (language) are matched to a student.

Third didactic principle: *Regularity of student and teacher's work*
Step 1 - Test Case Description: Students and teachers have regular contact, aided by AI bot chat, which stimulates communication.
Step 2 - Pre-Conditions: A bot chat should be designed with a set of communication activities.
Step 3 - Test Steps: A design of a chatbot and its implementation in the communication process between students and a teacher and between students.
Step 4 - Expected Result: The principle of regularity is maintained thanks to chatbot implementation.

Fourth didactic principle: *Conscious and active participation of learners in learning and teaching processes*
Step 1 - Test Case Description: Realizing this principle requires a real engagement of students and teachers in the didactic process. It means that students have to experience meaningful activities that foster their self-learning. The role of a teacher is to monitor students' progress, provide some hints, and maintain a friendly atmosphere. Also, checking whether students like it and if the system creates a proper learning path. For instance, IT tools can foster teachers' work by viewing the time spent on a specific issue or interactions with particular tasks. On this basis, a teacher can create a new learning pathway that algorithms could not elaborate on (especially at the earlier stage of system implementation).

Step 2 - Pre-Conditions: The system provides activities for a learner, but a teacher verifies their appropriateness (especially at the early stage of system work). Students can also mark the activity as necessary or unnecessary.
Step 3 - Test Steps: Specific content is proposed to a student to provide conscious and active learners' participation in educational processes. Time spent and engagement in the task indicate this didactic principle. Active feedback from students also builds a teacher's confidence about the appropriateness of the didactic content. In case of dropping out of the task, a teacher monitors the learning progress and proposes a new learning path, task, or different teaching materials. Then, it checks if there is any improvement.
Step 4 - Expected Result: Students and teachers actively participate in a didactic process, with mutual benefits concerning their experience.

Fifth didactic principle: The operability of students' knowledge
Step 1 - Test Case Description: The system provides the possibility of using knowledge in a particular context (in practice). It means there are tasks which are preceded by pills of knowledge. The tasks must be matched according to the student's preferences and levels of knowledge.
Step 2 - Pre-Conditions: A set of practical tasks has to be created for students (considering their preferences and levels). The system has to recognize if a student is ready to take on practical tasks.
Step 3 - Test Steps: After serving pills of knowledge, the system matches practical tasks according to the student's preferences and levels of knowledge.
Step 4 - Expected Result: Students operate new knowledge by using it successfully in practical tasks.

Sixth didactic principle: *The relationship between theory and practice*
Step 1 - Test Case Description: Practical tasks should correspond to the theory served in the course. According to the principle, students should know why they learn a specific issue. Also, before starting a lesson, students will be familiarized with the possibilities related to the course completion.
Step 2 - Pre-Conditions: Theory is preceded by a description of its application. Also, an attractive presentation of possibilities with a course completion (links to websites with
job offers, earnings).
Step 3 - Test Steps: Before choosing the course, students gain information about the application of knowledge as well as prospects and possible employment (it is possible to browse the information on job announcements portals and job rankings).
Step 4 - Expected Result: Learners know the necessity of learning theory for solving practical problems and its future application in professional development.

Seventh didactic principle: *Forming learning skills*
Step 1 - Test Case Description: Students need to adjust to the system and build a habit of learning skills. It means they actively participate in learning and use interactive functions (such as marking if they like the content and activities) to communicate their preferences. Specific habits can be trained thanks to the communication between a student and a system (and a teacher). Also, adequate pills of knowledge foster their striving to get more knowledge.
Step 2 - Pre-Conditions: The system should possess the functionality to evaluate activities and tasks. Also, the tasks should be personalized to engage students in the learning process.
Step 3 - Test Steps: The system provides students with adequate tasks and activities, matches tests for individual levels and preferences, and provides the possibility of feed back regarding teaching content.
Step 4 - Expected Result: Thanks to the system's functionalities, the students become motivated to strive for knowledge. They use the system regularly and perceive it as attractive. By providing positive stimuli, students perceive learning as a positive activ ity, recognize their needs, and learn how to learn.

Eight didactic principle: *The principle of continuing education*
Step 1 - Test Case Description: The system delivers up-to-date courses which can help improve professional development. The courses as reusable learning objects are editable for future updates.
Step 2 - Pre-Conditions: Courses in a standardized format can be taken. They are readily available, intuitive, and engaging. Teachers are engaged in the content evaluation and send feedback to administrators.
Step 3 - Test Steps: Instructional designers prepare with subject matter experts' courses (can be editable for updates). The choice of courses is available on the platform. Students can take them anytime, anywhere. Teachers have tools for reporting any outdated content.
Step 4 - Expected Result: The principle of continuing education is fulfilled by ensuring up-to-date educational possibilities and fostering professional development.

5.2 Manners of realization of didactic principles by AI

In order to find out standard foundations for the content of use cases, it can be observed that AI can facilitate the realization of didactic principles in educational endeavors in three manners: by providing 1) personalized learning content, 2) individual assessment, 3) and meaningful interactions (between students, students and a teacher, students and

the system, also a teacher and the system). Personalized learning applies to a stage of learning where the instructional approach is optimized for the needs of each learner. It improves learning outcomes and increases learners' satisfaction, motivation, and engagement [16]. Personalized learning content is possible thanks to adopting an individual approach in which students receive materials designed according to their preferences, learning styles, and levels. This approach optimizes opportunities for effective and enjoyable learning, enabling students to concentrate on their studies, minimize distractions, reflect on their contributions and adapt their learning to fit their work schedule. By preventing fluctuations in motivation, personalized learning ensures a consistent learning experience [17]. This is revealed in use cases in the following excerpts: “the AI can choose appropriate learning content for a student”, “the pills of knowledge are chosen based on the test results", and "the system matches practical tasks according to the student's preferences and levels of knowledge”, “provides students with adequate tasks and activities”. The possibility of providing personalized learning content enables the realization of most didactic principles. Individual assessment is essential for personalized learning and performance predictions. Through the use of learning analytics, it is possible to make performance predictions [18]. The use cases' content contains the following expressions, creating this category: "Pretests concerning the level of knowledge and learning preferences are conducted to evaluate students' level" and “matches tests for individual level and preferences”. Meaningful interactions can be created with AI [19], and AI assistants, which aid in creating meaningful interactions, could help students stay engaged and learn content [20]. The category of meaningful interactions is present in the use cases regarding the following excerpts: “Students can communicate the choice by likes and dislikes (social media pattern)“, “a real engagement of students and teachers in the didactic process”. The distinguished categories help to understand better the role of AI in the achievement of didactic principles.

6 Conclusions

The qualitative analysis of the use cases indicates that AI can easily foster the implementation of didactic principles, particularly in the newly developed mobility platform. AI can facilitate the realization of didactic principles in educational endeavors in three key aspects:

1) Personalized learning activities and content - personalized education is a highly individualized education system optimized for the needs of a particular student. It is flexibly adapted to the learner's participation. This style of education assumes the selection and adaptation of methods, techniques and ways of teaching.
2) Individual assessment - enables platform users to take ownership of their learning by judging the extent of their knowledge, skills, competencies and understanding. It

provides a structure for them to reflect on their work, what they have learned and how to improve. Through individual assessment, learners take more responsibility for their learning. It helps learners assess their development objectively, crystallize learning objectives, recognize their knowledge, skills, and attitudes, think about what they did not understand, grow in confidence, and take their learning forward.
3) Achieving learning goals - AI learns by implementing feedback the way a teacher would like it implemented by a participant in our training. Thanks to this functionality, the learner can count on its support in almost every task. This increases the effectiveness of learning, the chance of implementing new educational methods, and the number of people signing up as platform users. Artificial intelligence can see dependencies where a human would not even be able to put forward hypotheses, which is the beginning of a revolution in education.

The three features apply to the educational mobility context. As mobility is related to communication in different cultural environments, artificial intelligence can help learners and teachers communicate and understand mutual needs and requirements. A culture may hinder achieving didactic goals, and scholars and practitioners perceive varied groups as challenging [21].

The results of our study of artificial intelligence conducted on the eMediator platform show that artificial intelligence is valuable and can be used to implement didactic principles for a state-of-the-art mobility platform. However, at the current stage of development, artificial intelligence should only supplement human activities (teacher, coach, mentor, trainer); it cannot be used thoughtlessly. Having assumed that the education system largely relies on shaping human intelligence, a dilemma arises: Can or should artificial intelligence interfere in shaping the human intellect and personality in the process of education? This dilemma is all the more justified as the assumptions guiding AI solutions' creators relate mainly to the needs of enterprises, transmission and the economy. Thus, AI may be useless or even harmful if left thoughtlessly used for the needs of the education system. What "Optimization" and "increasing efficiency" mean in business does not necessarily mean the same in education, regardless of its stage. For example, it is unnecessary to develop an attitude of tolerance that will be more effective if the student learns twice as fast with twice as many works of art per unit of time.
Further implications are connected with the system's development and testing of the use cases. Also, it could be possible to compare use cases with others from other similar projects to verify whether the solutions are designed in a way that optimizes learning.

This work was funded by the EU grant of the ERASMUS+ project eMEDIATOR (Agreement No. 2021-1-LV01-KA220-HED-000027571).

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