



Pedagogical framework and user requirements

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Conversational AI assistant for teaching and learning

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Executive Summary

This deliverable presents some possible theoretical underpinnings of the AI4EDU project from the field of philosophy of education. In particular, it studies some ways in which Artificial Intelligence (AI) technology in general – and in particular such technology as the one that the AI4EDU project aims at developing – can support, and be supported by, four different, but somewhat connected, educational strategies. These are scaffolding, student-centered education, inquiry-based education, and dialogic education. Thus, this deliverable takes as departure points several central topics within the philosophy of education and investigates whether each of these didactical strategies can be supported and furthered by AI education. Moreover, the deliverable thereby also investigates whether the inclusion of AI technology in education can be motivated by arguing that it makes the respective educational endeavor more efficient or likely to succeed or reach a higher potential. In short, it is argued that while each of these four didactical strategies are important and has merits of its own, in each case there are also compelling ways in which the AI tools under development can overcome some limitations or challenges related to each of these strategies respectively. Thus, this investigation advances several reasons in favour of adopting AI technology in school, but also provides some guidance and suggestions as to how it can be used to reach educationally important quality improvements in school.

Moreover, the deliverable reports on the end user requirements for the AI4EDU conversational AI tools for students and teachers. More specifically the deliverable presents the methodology followed and the analysis conducted on data collected from several workshops in the four project countries with students and teachers, aimed to gather end users' insights on several aspects of the AI4EDU tools, such as acceptance, usability, benefits, risks, and suggested functionalities and use case scenarios. The outcomes of this task are exploited for defining the technical specifications of the AI4EDU applications in D2.2.

Acronyms and abbreviations

Abbreviation	Description
AI	Artificial Intelligence
AI4EDU	Artificial Intelligence for Education (project name)
CoI	Community of Inquiry
ICT	Information and Communication Technology
LLM	Large Language Model
P4C	Philosophy for Children
PwC	Philosophy with Children
P4wC	Philosophy for/with Children
SCL	Student-centered learning
SDGs	Sustainable Development Goals
SEN	Special Educational Needs
VTA	Virtual Teaching Assistant
ZPD	Zone of Proximal Development

1. Introduction

This deliverable details some possible theoretical underpinnings of the AI4EDU project from the field of philosophy of education.

It should be noted that there are many possible ways to motivate and seek a theoretical rationalization of the project. Hence, no single paper can investigate all of these. This deliverable, therefore, will discuss some influential ideas from within philosophy of education, and scrutinize whether each of them, respectively, can offer a rational underpinning of the project and its main ideas. It will also discuss whether they all taken together provide support to the project. The main aim of this deliverable is to investigate potential ways in which AI technology, if designed, implemented, and used properly, could potentially benefit education, considering also potential risks, shortcomings, challenges, or adversities that the inclusion of AI technology in educational settings might pose, as expressed by students and teachers during the procedure of collecting end users' requirements.

1.1. Introducing AI technology in education

The interest in AI has exploded during 2023, and among the most discussed questions relating to AI technology are questions relating to education. In particular, much focus has been put on so-called Generative AI, and especially in the form of LLMs. This fairly new technology gives rise to many important questions, possible problems and potential dreams about what education can and ought to be, and how this technology might have an impact on education as we knew it a few years ago. As such, there are too many topics for us to raise them all here. Instead, we will focus on a few key topics, which we consider to be of high educational value and importance, and in which there are also potential impacts by AI technology.

1.1.1. Digital competencies

It would be impossible for the aims and objectives of the project not to be in line with the pedagogical framework concerning the digital competences of teachers and students. The EU strategy for digital skills, along with associated policy initiatives, is specifically designed to augment digital proficiencies and competences in the context of ongoing digital transformation. These efforts are aligned with the Digital Education Action Plan, aimed at i) enhancing digital skills and competences to facilitate the digital transformation, and ii) nurturing the development of a highly effective digital education system. Moreover, the Digital Compass and the European Pillar of Social Rights Action Plan articulate ambitious policy objectives, specifically targeting a minimum of 80% digital skill proficiency among the population and the attainment of 20 million information and communication technology (ICT) specialists by 2030. The latest version of the Digital Competence Framework for Citizens (DigComp2.2) provides more than 250 new examples of knowledge, skills, and attitudes (competences) that help citizens engage confidently, critically, and safely with digital technologies, and new and emerging ones such as systems driven by AI. Furthermore, DigComp2.2 highlights the imperative need for the proficiency of citizens in confidently, critically, and safely interacting with novel and evolving technologies, particularly those propelled by AI. In addition, the enhanced awareness on data protection and privacy, ethical considerations, the rights of children, and biases present in systems, such as those related to accessibility, gender, and disabilities should also be considered. It is noteworthy that the DigComp 2.2 update, rather than focusing exclusively on the theoretical knowledge pertaining to AI, directs attention to the practical aspects of citizens engaging with AI systems.

This strategic emphasis is designed to equip individuals with the competencies necessary for meaningful and responsible interaction within the contemporary technological landscape.

1.1.2. Adaptive pedagogy

The evolution of AI in education has progressed from basic rule-based systems to sophisticated machine learning algorithms, unlocking possibilities for personalized instruction and adaptive learning. The ongoing advancements in AI language models hold immense potential to revolutionize education by delivering more effective and tailored learning experiences for students and equipping educators with intelligent tools to enhance their teaching practices.

A significant aspect related to AI Language models in education is their impact on adaptive and personalized learning. A systematic review on AI-based language learning tools submitted on 29 October 2021 reports that different types of learners demonstrated gains in their language abilities and knowledge. In addition to the above the concept of adaptive learning, rooted in constructivist theory, posits that learning is shaped by pre-existing knowledge (Schunk, 2012). The logical algorithms employed by ChatGPT and similar language dialoging models, which construct new knowledge from existing information, are in harmony with this theoretical framework (Hein, 1991). Consequently, ChatGPT emerges as a valuable tool for fostering a constructivist approach to learning (Rudolph et al., 2023).

1.2. Literature review

1.2.1 Evolution of Computer Technology

In the past fifty years, the exponential growth of computer technology has significantly transformed various aspects of our daily lives. Initially confined to workplaces for data processing, computers have undergone a remarkable evolution, transitioning from mere computational tools to ubiquitous personal devices present in households. Today, these devices, functioning as intuitive assistants, are conveniently carried in pockets, providing constant internet connectivity, and enabling a wide range of tasks to meet diverse user needs. This evolution underscores technology's ability to adapt and evolve, aligning with the dynamic requirements of its user base.

1.2.2 Multi-Domain Impact of Computer Technology: A Review Across Diverse Sectors

Extensive scholarly research has documented the pervasive presence of computers across different disciplines. They have become indispensable tools in sectors such as healthcare, finance, entertainment, and education, each leveraging their distinct capabilities to enhance efficiency, foster innovation, and improve accessibility.

In healthcare, computers have revolutionized care delivery and management. Studies such as the one by Hillestad et al. (2005) demonstrate the potential of health information technology to save over \$81 billion annually in the United States by improving efficiency and safety. Technologies like telemedicine and electronic health records have empowered remote healthcare delivery and data-driven decisions (Mair & Whitten, 2000).

The finance sector has witnessed transformative changes through computer-based algorithms, facilitating high-frequency trading and intricate financial modelling (Aldridge, 2013). Additionally, financial technologies or 'fintech' have expanded access to financial services through digital platforms (Zavolokina et al., 2016).

The entertainment industry has undergone significant shifts due to computer technology. Platforms like YouTube, as explored by Burgess & Green (2018), have altered media

production and consumption, providing more people with the opportunity to create and share media. Furthermore, digitization, as investigated by Manovich (2001), has not only changed how we create and access media but has also reshaped our concepts of 'media', 'computation', and 'data'.

These examples underscore the extensive and profound influence of computer technology across various sectors. As technology continues to evolve, it is poised to impact more areas of society, continuously responding to, and shaping our evolving needs. The subsequent sections will delve into the detailed implications of this evolution in the context of education.

1.2.3 AI in Education

AI has made notable strides in the realm of education, introducing innovative approaches to enhance teaching and learning. This section will delve into recent studies illustrating these advancements.

Various studies have investigated the integration of AI chatbots in education, showcasing their potential as intelligent student assistants. In one study, Pereira (2016) explored the use of chatbots to improve self-guided learning through conversational quizzes. The study introduced Dawebot, a chatbot on the Telegram platform that enables interactive quizzes and immediate feedback. The results revealed that students found the chatbot valuable, especially for test practice, citing benefits such as immediate feedback, ease of use, and continuous progress tracking.

Ho (2018) conducted a study on "TA-bot: An AI agent as a Teaching Assistant," presenting an AI agent designed as a virtual teaching assistant. TA-bot successfully served as a specialized assistant in a Digital Marketing class at George Mason University, offering information and answering student inquiries related to the course syllabus. The study emphasized the potential of virtual teaching assistants, like TA-bot, to address staff shortages in educational settings and enhance the learning experience.

Benedetto & Cremonesi (2019) introduced an innovative architecture called Rexy for constructing virtual teaching assistants (VTAs). Rexy, utilizing IBM's Watson Assistant, demonstrated positive feedback from students in reducing professors' workload. The study identified areas for improvement, emphasizing Rexy's promise in implementing VTAs and suggesting future enhancements.

Dokukina & Gumanova (2020) explored the use of chatbots as interactive tools for language education. The study discussed the role of chatbots in providing structured interactions, mentoring, and practice for language skills, emphasizing their convenience and accessibility for language learners.

In a study by Dimitriadis (2020) titled "Evolution in Education: Chatbots," the potential application of chatbots in educational settings was examined. The study discussed the advantages and disadvantages of using chatbots, emphasizing their potential for personalized and adaptive learning. While acknowledging the early stages of chatbot integration into education, the study highlighted their benefits in relieving teachers from repetitive tasks and enhancing the learning process, calling for further research in this evolving field.

A study by Chen et al. (2022), titled "Artificial Intelligence (AI) Student Assistants in the Classroom: Designing Chatbots to Support Student Success," investigated the role of chatbots in higher education. The research aimed to assess the effectiveness of chatbots as interactive learning tools, focusing on teaching basic AI concepts, enhancing student

engagement, and reducing educators' workload. While students generally perceived chatbots as valuable additions to the classroom due to their interactive nature and responsiveness, the study highlighted limitations, including the inability to fully replicate human conversation or emotional responses. The research called for advancements in chatbots' intelligence and emotional understanding, considering ethical implications in educational settings. Another study by Haderer & Ciolacu (2022), "Education 4.0: Artificial Intelligence Assisted Task- and Time Planning System," explored the integration of AI in education. The study presented an AI-based system focusing on task and time planning for students to enhance self-regulated learning. Emphasizing the importance of digital tools and AI in Education 4.0, the paper discussed technologies like adaptivity, personalization, AI advice, gamification, and the Internet of Things. The proposed system utilized AI engines for personalized recommendations and adaptive learning experiences, emphasizing the need for data integrity and security. Lastly, Boateng et al. (2022) conducted a study titled "Kwame for Science: An AI Teaching Assistant for Science Education in West Africa" to address educational challenges. The study adapted Kwame, an AI teaching assistant, for science education in West Africa, demonstrating promising results in delivering scalable, cost-effective, and quality remote education. These studies collectively contribute to exploring AI in education, showcasing the potential of chatbots and AI-based systems to enhance learning experiences, provide personalized assistance, and address educational challenges.

Table 1. AI roles in education.

Paper Title	Pros	Cons	Use-case	Evaluation Criteria
Leveraging chatbots to improve self-guided learning through conversational quizzes	<ol style="list-style-type: none"> 1. Increased engagement 2. Improved accessibility 3. Immediate feedback 	<ol style="list-style-type: none"> 1. Not designed for mobile devices 2. High consumability effort 	<ol style="list-style-type: none"> 1. Interactive learning experiences 2. Feedback on answers 3. Hints and tips 4. Personalized learning paths 5. Facilitate collaboration between learners and instructors 	<ol style="list-style-type: none"> 1. Correlation between the number of quizzes tried and the score of the final test 2. Correlation between the number of quizzes well answered and the score of the final test 3. Correlation between the final score and the usage of the bot
TA-bot: An AI agent as a Teaching Assistant	<ol style="list-style-type: none"> 1. Effectively aids understaffed educational institutions by providing virtual assistance. 2. Handle queries about syllabus content, assignments, exams, and more, assisting students with course-related information. 3. Leverages commercial off-the-shelf software, making it a cost-effective solution. 	<ol style="list-style-type: none"> 1. Specialized only in answering syllabus-related questions and cannot handle other types of queries or tasks. 2. The maintenance of knowledge about the class is done through two different interfaces, which could make the management process cumbersome 3. Built specifically for a class, limiting its scalability across different courses without additional customizations 	<ol style="list-style-type: none"> 1. Providing information about a course's syllabus, assignments, exams, and deadlines. 2. Responding to questions about where and when the course meets. 	<ol style="list-style-type: none"> 1. Capability to answer varied course-related queries: The bot should correctly respond to inquiries about the syllabus, assignments, exams, deadlines, and more. 2. Integration with used platforms: The bot should seamlessly integrate with platforms commonly used by students, like Facebook Messenger. 3. Ease of maintenance: How easily can the bot's knowledge be updated or modified through its interfaces.

Rexy, a configurable application for Building Virtual Teaching assistants	<ol style="list-style-type: none"> 1. It provides immediate answers. 2. It reduces the workload on professors. 	<ol style="list-style-type: none"> 1. The threshold value that decides whether to accept the answer or ask a teacher has an impact to the performance. 2. Only one-to-one interaction. 	<ol style="list-style-type: none"> 1. The Rexy application can be used to build Virtual Teaching Assistants (VTAs) that can answer general requests from students. 	<ol style="list-style-type: none"> 1. Feedback from students. 2. Assessing the accuracy of the application in detecting the correct intent. 3. Measuring the average time elapsed between sending a question and receiving the answer. 4. Workload on the professor.
The rise of chatbots – new personal assistants in foreign language learning	<ol style="list-style-type: none"> 1. Cost-effective language learning tool. 2. Convenient 24/7 availability. 3. Immediate feedback provision. 4. Judgement-free learning environment. 	<ol style="list-style-type: none"> 1. Not effective for unstandardized communication. 2. Less suitable for advanced learners. 3. Limited natural language processing ability. 	<ol style="list-style-type: none"> 1. As intelligent tutoring systems. 2. Interactive language tutorials. 3. Role-playing in quizzes and storytelling. 4. Responding to standardized customer queries. 	<ol style="list-style-type: none"> 1. Suitability for specific student proficiency levels. 2. Appropriate conversational response capability. 3. Operates 24/7.
Evolution in Education: Chatbots	<ol style="list-style-type: none"> 1. Can be used for personalized and adaptive learning in educational settings. 2. Can relieve teachers of repetitive tasks. 3. Aids in customer support, information retrieval, and business solutions. 4. Can be used for promotion of products. 	<ol style="list-style-type: none"> 1. Can cause misunderstandings in communication. 2. Excessive reliance on chatbots may impact human relationships and social interactions. 3. Inability to handle complex tasks or negotiations. 	<ol style="list-style-type: none"> 1. Customer support in various industries. 2. In educational institutions for scheduling, reminders, and course information. 3. In businesses for product promotion. 	<ol style="list-style-type: none"> 1. Accuracy and reliability of responses. 2. Ability to learn and improve responses over time. 3. Flexibility in providing services anytime without being restricted by opening hours. 4. Degree of humanization without leading to misunderstandings. 5. Efficiency in handling repetitive and predictable tasks. 6. Minimal financial resources and organizational structures required.
Artificial Intelligence (AI) Student Assistants in the Classroom: Designing Chatbots to Support Student Success	<ol style="list-style-type: none"> 1. Teach basic content & answer basic questions. 2. Encourage exploration of additional resources. 3. Assist with career- and life-related issues. 4. 24/7 responsiveness. 5. Assist students through conversations 	<ol style="list-style-type: none"> 1. Losing the flow of the dialogue. 2. Lacking the capacity for emotional comprehension in students. 3. Not able to understand open-ended answers. 4. Inability to react in real-time to student comments and questions. 	<ol style="list-style-type: none"> 1. Multiple-choice quizzes. 2. Answering frequently asked questions. 3. Answering basic course and content questions. 4. Ability to encourage further exploration of additional resources. 5. Language learning. 	<ol style="list-style-type: none"> 1. By quiz results. 2. Objective data, test scores, and student opinion of their learning experience.

	which leads to engagement. 6. Shy students can ask any question freely.			
Education 4.0: Artificial Intelligence Assisted Task and Time Planning System	<ol style="list-style-type: none"> 1. Automatically generated tasks from the AI Engines. 2. Secure data exchange via the Open API Service. 3. Ability to monitor and view learning progress and success. 4. Gamification of working through courses. 5. Consideration of different learning types, strengths, and weaknesses. 6. Notification messages to alert students of learning arrears. 	<ol style="list-style-type: none"> 1. Lack of personalization and customization for individual students. 2. Potential for data security and privacy issues. 3. Difficulty in understanding complex tasks and instructions. 4. Difficulty in providing accurate and timely feedback, notifications and reminders, and assessment tasks. 	<ol style="list-style-type: none"> 1. Tailored learning content. 2. Reminders and notifications about tasks and learning progress. 3. Provide assessment tasks. 4. Coordinate automatically and manually generated tasks. 5. Monitor and view learning progress and success. 	<ol style="list-style-type: none"> 1. Usability. 2. User experience. 3. Data protection. 4. Data security. 5. Communication between layers.
Kwame for Science: An AI Teaching Assistant for Science Education in West Africa	<ol style="list-style-type: none"> 1. Providing instant answers to science questions. 2. Ability to fine-tune the SBERT model to improve accuracy. 3. Making Kwame for Science available in local languages across Africa. 4. Making it available via offline channels such as SMS, USSD, and toll-free calling. 	<ol style="list-style-type: none"> 1. Challenging cases when there are typos in the spelling of scientific words. 2. Questions related to topics outside the scope of the knowledge source. 3. Unhelpful answers due to issues with the dataset. 	<ol style="list-style-type: none"> 1. Providing instant answers to science questions of students. 	<ol style="list-style-type: none"> 1. Top 1 accuracy quantify performance assuming only one answer was returned and voted on. 2. Top 3 accuracy refers to the performance where for each question that received a vote, at least one answer was rated as helpful out of the 3 answers that were returned.

2. Collection of user requirements

2.1 User requirements collection methodology

Before proceeding to the investigation of the theoretical underpinnings of the AI4EDU project, we first describe our methodology for gathering user requirements from teachers and students. The aim of this task is to outline the needs, expectations, and preferences of our target audience, i.e., educators, students. By understanding these requirements, we can ensure that the conversational AI tools that the project aims to develop are pedagogically sound and tailored to effectively meet the diverse learning and teaching objectives. Here, we will detail the methodologies employed to gather these insights, analyze the data, and how this will shape the development of the AI4EDU tools to enrich the educational experience.

For the collection of students' and teachers' requirements several workshops have been carried out from February to October 2023 (Table 2). These workshops have spanned several countries and totaled over 250 participants (Fig. 1). During the workshops, the participants were given the opportunity to test different AI tools and to reflect upon both current uses of AI technology and possible future use cases, offering valuable data that enabled the definition of user requirements and guided the definition of technical specifications (reported in D2.2).

Table 2: Information on workshops with students and teachers conducted by project partners

Partner	Workshop	Date	No of participants
ARC	Student	19-06-2023	7
ARC	Teacher	07-06-2023	8
ARC	Teacher	07-09-2023	15
EA	Student	31-05-2023	70
EA	Teacher	20-06-2023	11
DEC	Teacher	22/23-02-2023	19
DEC	Teacher	09-03-2023	35
DEC	Student	05-07-2023	22
DEC	Student	03-10-2323	8
DEC	Teacher	05-07-2023	18
DEC	Teacher	03-10-2023	10
CPI	Student	23-06-2023	17
CPI	Teacher	23-06-2023	11
LTU	Teacher	07-09-2023	7
LTU	Student	24-08-2023	22

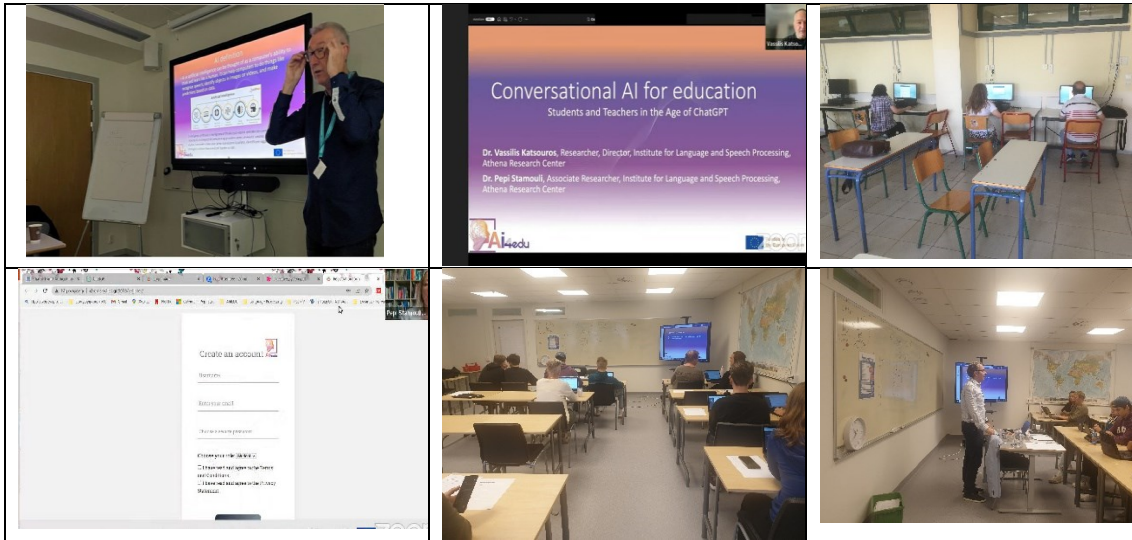


Figure 1 Photos from workshops with teachers and students

Collecting user requirements involved a systematic and collaborative approach which was discussed and agreed by all project partners and can be outlined as follows:

- **Workshop objectives:** The workshops' objectives were clearly outlined and explained to workshop participants: understanding the specific needs and expectations of both teachers and students regarding the AI4EDU conversational AI assistants.
- **Workshop Planning:** Each partner identified and invited the workshop participants (Teachers, Students) and scheduled the workshops at convenient times for them. Planning of workshops sometimes was the outcome of collaboration between project partners of the same country. Workshops were planned either as project-specific events or on the occasion of educational events already planned by the project participants, such as summer schools or educational seminars. Two different workshops were conducted for the different target groups (Appendix 1).
- **Workshop Execution:** The workshops focused on facilitating discussion between project team members and participants and for capturing feedback. These aims were achieved successfully by designing practical exercises related to the participants by using available AI technologies, such as Large Language Model-based ChatGPT (LLM). Moreover, participants' interaction with the AI4EDU prototype, already developed at the time of workshops and available for use, facilitated the execution of hands-on activities on several educational tasks.
- **Survey distribution:** Three distinct surveys were administered throughout the workshop. The initial survey, conducted at the workshop's onset, aimed to assess the participants' comprehension of existing AI tools. The second survey sought feedback after the participants interacted with conversational AI tools, such as ChatGPT, or after demonstrating the capabilities of ChatGPT in educational settings. Finally, the last survey was designed to gather insights following the participants' interaction with the prototype developed by the AI4EDU team.
- **Data analysis:**
 - **Quantitative Analysis:** Quantitative data from surveys were analyzed to identify trends and preferences among the stakeholders (Appendix 2).
 - **Qualitative Analysis:** Qualitative data from workshop discussions, as well as from textual interactions of participants with the AI4EDU prototype were reviewed, to identify recurring topics, challenges, and suggestions (Appendix 3).

- **Compile findings:** Findings from both workshops and surveys were compiled and synthesized.
- **Requirements Specification:** Gathered insights were translated into clear and actionable requirements for both stakeholders and the development team. The analyzed data will have impact on the following:
 - User experience and acceptability
 - *Study Buddy* (conversational AI tool for students) technical specifications (functional and non-functional requirements, see D2.2)
 - *Teacher Mate* (conversational AI tool and dashboard for teachers) technical specifications (functional and non-functional requirements, see D2.2)
- **Validate requirements:** The compiled requirements were validated with key stakeholders, including teachers, students, and project team members, to ensure that the identified requirements align with the project goals.
- **Report creation:** The entire process is documented, including methodologies used, participant feedback, and finalized requirements from both pedagogical and technical perspectives. D2.2 focused on the technological requirements while D2.1 focuses on pedagogical framework and user requirements.

2.2 Data analysis – User requirements

This section involves a systematic examination of data gathered through a presented methodology, including workshops, surveys, discussions with teachers and students, as well as selective analysis of participants' interactions with the AI4EDU conversational prototype, the Study Buddy and the Teacher Mate. The project team actively participated in these sessions, contributing to a qualitative dataset. In the next sections, the information processed from the data to serve different aspects of user requirements will be discussed in detail.

2.2.1 Potential Benefits

Student Workshop

The following questions in the survey were designed to extract the potential benefits of using AI tools:

- *What would you like AI to be able to help you with, in your studying?*
- *According to your experience with the Study Buddy tool, in what ways is this tool going to be helpful to you? How do you plan to use it during your work at school, after school, and beyond school?*

These questions that were asked to students were analyzed by the different project partners and some of the potential benefits highlighted are summarized below:

For students, their responses primarily focused on the positive aspects of AI engagement. They highlighted Study Buddy's potential to simplify homework, gamify learning, and help in understanding complex concepts.

Teacher Workshop

The following questions in the survey were designed to extract the potential benefits of using AI tools:

- *What kinds of things that you currently do in your work would you like AI technology to be able to accomplish for you, or to assist you with doing?*
- *Please describe how this technology might affects your students' (positively or negatively or not at all)*
- *What do you think would be the students' reactions when working with these technologies?*
- *According to your experience with the teacher assistant tool, in what ways is this tool going to be helpful to you? How do you plan to use it during your work at school, after school, and beyond school?*

These questions that have been asked to teachers were analyzed by the different consortium partners, and some of the potential benefits highlighted by teachers of using AI tools by both teacher and students are summarized below:

The integration of AI tools in education presents a myriad of benefits aimed at enhancing the overall learning experience. Firstly, these tools play a pivotal role in fostering creativity, collaboration, and skill development among students. Additionally, they contribute to operational and administrative efficiency within educational institutions. AI tools serve as valuable aids by providing hints for research, stimulating interest, and introducing gamified elements into the learning process. Students also gain practical experience in utilizing technology constructively, particularly in areas such as essay writing. By incorporating AI into education, students are brought closer to technological developments, fostering engagement and relevance in their learning journey. AI tools contribute to a deeper understanding of concepts, offering clarification and activating students' attention and engagement. Moreover, they play a crucial role in cultivating AI literacy, thereby enhancing critical thinking skills through the evaluation of AI responses. However, it's important to note that the positive impact of AI in education can be fully realized when the entire educational system undergoes a transformation, providing ample time and opportunities for personalized teaching and learning experiences for both teachers and students.

2.2.2 Risks and Concerns

Student Workshop

The following questions in the survey were designed to discover the risks and concerns of using AI tools by students:

- *According to your experience so far with AI technologies, what are the fears that you have towards using AI in education? Please explain.*
- *To which extent AI should be used in future learning and education?*

These questions that have been asked to the students were analyzed by the different partners of this project. The risks and concerns shared by them are summarized below:

Students express valid concerns regarding the use of AI in education, emphasizing the potential risks associated with excessive reliance on technology. They fear that an overemphasis on AI might lead to a loss of genuine connections with people, highlighting the importance of real interactions for fostering creativity and critical thinking. There is skepticism among students about the reliability of AI, with concerns raised about the possibility of receiving incorrect answers and the ease with which misinformation can spread. Students emphasize the importance of ensuring the accuracy of their learning experiences, acknowledging the need to verify information. Despite these reservations, there is a

recognition that having a tool to assist with everyday homework is appreciated, demonstrating a nuanced perspective that balances concerns with the potential benefits of AI in education.

Teacher Workshop

The following questions in the survey were designed to find out the risks and concerns shared by teachers in case of using AI tools by both teachers and students:

- *Please describe how this technology might affect your students' (positively or negatively or not at all)*
- *According to your experience so far with AI technologies, what are the fears that you have towards using AI in education? Please explain.*

These questions that have been asked to teachers were analyzed by the different partners of this project. The risks and concerns shared by teachers of using AI tools are summarized below:

The incorporation of AI technology in education raises several risks and concerns, particularly in the context of schools in some European countries like Greece that currently lack sufficient technology infrastructure. One major apprehension is the fear that adopting AI could exacerbate social discrimination, creating disparities between schools deemed "advanced" and those considered "poor", thus perpetuating existing inequalities among students. Another concern revolves around the potential misconception among students that AI possesses the capability to handle all tasks, potentially leading to a diminishing emphasis on human involvement. There is also a risk of noncritical copy-paste behavior, inhibiting creative and original thinking. The adoption of AI in education may further contribute to the loss of human interaction between teachers and classmates, potentially impacting social dynamics negatively. Additionally, there is a concern that the reliance on AI could lead to an increase in social inequalities and a loss of the essential skill of learning how to learn. Students might not fully realize the necessity to verify AI responses due to a lack of knowledge and expertise, potentially resulting in effortless yet error-prone work. Finally, there is a worry that the increasing authority and omnipotence of computers may have unintended consequences on the dynamics of education.

2.2.3 Acceptance and Readiness level

Conducting a fruitful discussion during the workshop to estimate and understand the acceptance and readiness level of using AI tools in education followed a structured approach:

- a) Participants were provided with a clear overview of the AI tools being discussed and their potential applications in education,
- b) Open dialogue was encouraged, inviting participants to share their thoughts, concerns, and expectations regarding the integration of AI into educational practices,
- c) hands-on activities or demonstrations were incorporated to allow participants to interact directly with AI tools. This practical engagement was aimed to provide valuable insights into their comfort level and potential barriers to AI adoption.

Discussions and activities as a kind of qualitative data were analyzed by the different partners in this project to share the level of acceptance and readiness in different schools as follows:

Teachers, while expressing a willingness to learn about AI technologies, harbor reservations about their widespread use in schools. They are concerned about the potential negative impact on students who might over-rely on technology and struggle to identify inaccuracies in AI-generated output. Teachers emphasize the critical need for comprehensive training programs that equip both educators and students with the skills for effective and responsible AI integration in education. Despite their concerns, there is a clear openness to exploring the possibilities offered by AI.

Students, on the other hand, are excited about the potential benefits of AI in enhancing their learning experiences. They are, however, aware of AI's limitations and potential errors. Importantly, students emphasize the significance of maintaining human interactions with teachers and classmates, recognizing the irreplaceable value of these connections in the learning process. This dual perspective from both teachers and students highlights the importance of a balanced and well-guided approach to introducing AI technologies in educational settings.

2.2.4 Suggested use case scenarios

Defining possible use case scenarios for AI adoption in education involves a multifaceted approach combining workshops and surveys. To engage teachers, workshops are conducted to identify their challenges and needs, followed by AI awareness sessions and brainstorming activities to explore potential applications in lesson planning, student assessment, and personalized learning. Surveys are then distributed to gather feedback on these workshops and pinpoint teachers' preferences. Similarly, workshops for students aim to understand their perspectives on learning and technology, with interactive sessions exploring AI applications. Surveys for students gather feedback on their comprehension and interest in AI, identifying areas where technology could enhance their learning. Collaborative workshops bring teachers and students together to create joint use case scenarios, fostering collaboration. Final validation surveys ensure that the scenarios align with the expectations of both groups, and refinements are made based on the feedback received, resulting in well-defined use case scenarios appreciated by both teachers and students.

The outcomes of these activities were analyzed by the different partners in this project to specify some use cases provided by teachers and students.

The participants in the workshop shared various insightful use cases for leveraging AI in education, illustrating its versatile applications. These include the creation of diverse educational resources such as tests, exams, lesson plans, worksheets, and teaching materials like notes and PowerPoint presentations. The potential of AI to personalize teaching materials for students with specific learning needs was highlighted. The teachers also recognized the efficiency of AI in scoring students' answers and its capability to identify common misunderstandings and misconceptions in science subjects. Further applications involve exploring Physics concepts and linking them to experiments, as well as involving teachers in the evaluation and validation of AI responses. AI was seen as a valuable tool for generating code, developing educational videos and graphs, and creating comprehension questions. Additionally, participants emphasized its role in organizing projects, workshops, and experimental sessions, collecting information on teaching subjects, structuring presentations, and providing ideas for engaging in-classroom activities. This comprehensive array of use cases reflects the potential of AI to enhance various aspects of the teaching and learning experience.

On the other hand, some failure use cases to use AI in education were also shared. AI proves less beneficial for lower secondary school levels, particularly in activities such as lesson

delivery, conducting tests and exams, maintaining personal contact with students, and managing classroom dynamics. AI also falls short in effectively teaching new subjects, as it lacks the capability to verify responses. Furthermore, it struggles to provide up-to-date knowledge and information and is limited in fostering students' critical thinking skills. These constraints highlight scenarios where the application of AI may not be as advantageous within an educational setting.

2.2.5 Recommended features

Teacher Workshop

The following question in the survey were designed to find out the features that the teachers aiming to have after experiencing using the Teacher Mate tool.

- *What are the features that you would like the Teacher Mate tool to be equipped with in order to be more helpful to you?*

The answers for this question have been analyzed by all partners in the project, and additional features suggested by the teachers are shared below:

To enhance the effectiveness and usability of AI tools in education, several recommended features should be considered. Integration of image creation capabilities, provision of preparatory examples to assist teachers in teaching specific topics, and catering to special needs education by offering alternative responses for children with learning difficulties are essential. Additionally, the tools should incorporate features such as creating graphs and math formulas, increasing the reliability of responses, suggesting experiments for understanding physical science concepts, and minimizing errors. They should provide model lesson plans for specific topics within designated time frames, grant access to online libraries and journals, and offer more practical lesson plans. Improving scientific validity, providing guidelines for correct and effective use, accommodating interaction with multiple textbooks (including materials created by teachers), ensuring compliance with copyrights, implementing safeguards for information control, and acknowledging the limitations of the application are crucial. Furthermore, tools for second language learning can be integrated to offer a comprehensive and versatile educational experience.

Student Workshop

The following question in the survey were designed to find out the features that the students aiming to have after experiencing using the Study Buddy tool.

- *What are the features that you would like the study buddy tool to be equipped with in order to be more helpful to you?*

The answers for this question had been analyzed by the different partners in the project, and some additional features suggested by the students are shared below:

Considering students' familiarity with Study Buddy, they would value features that enhance the interactive and visual aspects of learning. These could include not only interactive images but also the capability to import their own sources, fostering a more personalized learning experience. Gamified learning scenarios could add an element of fun and engagement to their studies, making the learning process more enjoyable. Additionally, real-time feedback mechanisms can provide instant insights into their progress, enabling students to adapt their approach and address any challenges promptly. Other beneficial features might involve collaborative learning tools, allowing students to work together on assignments and an

adaptive learning pathway that tailors the content to individual learning styles and progress. These features collectively contribute to a more dynamic and effective educational experience.

2.2.6 Conclusions

Data gathering for the development of AI tools for teachers and students involved workshops, discussions, and surveys conducted in four European countries (Greece, Cyprus, Ireland and Sweden). The collected data were analyzed and condensed into a set of questions and answers, presented in the table below. This approach aimed to yield valuable insights into the specific needs and preferences of both teachers and students, informing the ongoing development of AI tools in the educational context.

Question	Teachers	Students
1. Current AI Technologies in Use	Occasional ChatGPT utilization; Awareness higher than implementation.	Hands-on experience with Study Buddy AI assistant; - Potential showcased in classroom integration.
2. Teacher Mate Benefits	Excited about time-saving potential (lesson plans, tests); Concerns about creativity and critical thinking.	N/A
3. Study Buddy Benefits	Recognize potential to enhance research skills, engagement, and interest; Concerns about over-reliance on technology.	Focus on simplifying homework, Gamified learning, Understanding complex concepts.
4. Desired Features in Conversational AI Apps	Catering to diverse learning needs, Integration of existing educational materials, Assurance of scientific validity, Interaction with multiple textbooks, Image creation.	Gamified learning scenarios, Real-time feedback. Interactive images, importing own sources,
5. Challenges Addressed by AI	Simplifying complex tasks, Saving time, Engaging students effectively, Balancing workload and Following education standards.	Addressing challenges in understanding complex concepts, Conducting essays, Staying engaged during lessons.
6. Fears Regarding AI in Education	Concerns about societal impact, Technology disparities, Lack of critical thinking, and Over-reliance on AI.	Fear of losing real connections, Impact on creativity and critical thinking, Accuracy of AI-generated information.
7. Changes in Teachers' Opinions	Limited changes observed; Maintain cautious, open-minded attitude; Emphasize need for appropriate training.	N/A
8. Teachers' Confidence in AI Utilization	Willingness to learn but lack confidence; Highlight need for comprehensive training programs for effective AI integration.	Excitement about AI's potential while valuing human interactions with teachers and peers.

9. Suggestions for Teacher Mate	Customizable educational content (text, audio, video, interactive); Tailored suggestions based on students' performance; Integrated assessment tools.	N/A
10. Suggestions for Study Buddy	N/A	Interactive learning companion with natural language processing; Hologram interface; Personalized study plans; Gamified elements (quizzes, rewards, leaderboards).

2.3 Selected school subjects

The utilization of the conversational AI tools which are being developed in the AI4EDU project, designed for educators (Teacher Mate) and students (Study Buddy), is intended to cater to subjects within the realms of applied science (specifically the school subject of Biology) and humanities/social sciences (specifically the subjects of History and Social Sciences), as well as an interdisciplinary subject of Civil Education and Sustainable Development, across various grade levels. In applied science, exemplified by Biology, the AI tools for both teachers and students are expected to possess capabilities that facilitate practical application, data analysis, and problem-solving. In this context, the AI tools serve as facilitators, encouraging active engagement and enabling students to delve into real-world scenarios to cultivate practical skills. Regarding the humanities and social science subjects, the instructional emphasis may pivot towards fostering critical thinking, analyzing societal structures, and comprehending human behavior. Recognizing the divergent pedagogical requirements of these distinct domains, the collaborative efforts of the partners are directed towards addressing the unique needs of each subject, ensuring a tailored approach to applied science and humanities/social science education. The following table summarizes the school subjects of secondary education that were selected by project partners to be integrated into the AI4EDU tools for teachers and students with the aim to support teaching and learning objectives. The evaluation of the developed tools, in terms of both usability and educational impact, will focus on these specific subjects.

Table 3: Selected school subjects to be covered by the AI4EDU tools

Partner (Country)	Subject (Science)	Grade (Years)
DEC (Ireland)	Sustainable Development	Junior and Senior Secondary (12-17)
UCY & CPI (Cyprus)	Biology	Lower secondary (14-17)
LTU (Sweden)	Biology	Gymnasium (16-17)
EA (Greece)	Biology	Lower secondary (13-15)

Partner (Country)	Subject (Humanities & Social Sciences)	Grade (Years)
LTU (Sweden)	Social sciences	Gymnasium (16-17)
DEC (Ireland)	Civil Education	Junior and Senior Secondary (12-17)

CPI (Cyprus)	History	Lower Secondary (14-17)
EA (Greece)	History	Lower secondary (13-15)

3. Student-centered education and AI

In this chapter, we will address a pedagogical approach known as student-centered education and connect this to AI technology in education.

3.1 What is student-centered education?

The concept of student-centered learning has garnered interest in the last decades. There are several ideas connected to what is often called student-centered education, and there are somewhat fuzzy characterizations provided. There is the risk that a phrase like this becomes a catch-all phrase, thereby becoming quite vacuous. In a report by Gover et al. (2019) it is also stated that providing a “concrete definition [of student-centered learning] established at the institutional level” (ibid. p. 8) in fact “could, if perceived as rigid, have an adverse effect such as stifling creativity.” (ibid.). Instead, the report suggests that a “common understanding reached by means other than an explicitly defined statement can be just as effective” (ibid.). Below, we aim to give a characterization of student-centered education by detailing some of the ideas and features oftentimes associated with student-centered education. In later chapters, we will also present some concrete pedagogical approaches that can also be combined with, or can be seen as versions of, a student-centered approach to education. Thereby, we aim to contribute to the ongoing discussion about how to understand and implement student-centered education more precisely.

In a report by the European Students’ Union, Todorovski et al. characterize student-centered education by claiming that

“Student Centered Learning represents both a mind-set and a culture [...] and is a learning approach which is broadly related to, and supported by, constructivist theories of learning. It is characterised by innovative methods of teaching which aim to promote learning in communication with teachers and other learners and which take students seriously as active participants in their own learning, fostering transferable skills such as problem-solving, critical thinking and reflective thinking.” (Todorovski et al., 2015, iii)

Similarly, Gover et al. (2019), themselves partly citing (EHEA, 2009), state that student-centered learning can be

“defined as an approach that replaces purely transmissive models of education with an outcome-based perspective implemented through ‘new approaches to teaching and learning, effective support and guidance structures and a curriculum focused more clearly on the learner [...] leading to high quality, flexible and more individually tailored learning paths’ (EHEA, 2009, p. 3)” (p. 6)

Todorovski et al. provide further detail to the picture of student-centered education by providing some suggestions of some prerequisites of student-centered education, in the following:

“Student-centered learning requires empowering individual learners, new approaches to teaching and learning, effective support and guidance structures and a curriculum focused more clearly on the learner in all three cycles. Curricular reform will thus be an ongoing process leading to high quality, flexible and more individually tailored education paths.” (Todorovski et al., 2015, p. 4)

As we shall see below, student-centered education can also be characterized by contrasting it to another approach to education, sometimes seen as another paradigm, which we shall call the teacher-centered approach to education, which closely resembles what is sometimes called monologic education (cf. Gardelli, 2016), or, in the case of moral education in particular, the moral fostering or moral transmission approach (see e.g. Gardelli et al., 2014; Gardelli 2022). On this topic, Todorovski et al. claim that the failure of the traditional approach is part of the justification of a student-centered approach to education:

“The ineffectiveness of teaching through the transmission of knowledge has also been confirmed through years of pedagogical research. The massive protests, the rise of critical pedagogy and the research done on the teaching and learning process spawned the concept of student-centered learning; putting students in the driver's seat of their learning experience and facilitating the process of learning to learn.” (Todorovski et al., 2015, p. 1)

Indeed, much research has found monologic education, which can somewhat misleadingly be called traditional education (remember that in the dialogs of Plato, Socrates seems to be an early proponent or practitioner of a more dialogic, student-centered and inquiry-based form of learning, albeit that we can see room for improvement in Socrates's work as a facilitator and dialog partner – which shows that there are very early examples of these more modern forms of education, an interest in which has resurged in the present time, after a long spell of monologic education in Europe over the centuries), to be inferior in several ways (Gardelli, 2016).

Further arguing in favor of a student-centered approach to education, Todorovski et al. (2015) point to the changes in the landscape of higher education as a driver of interest in student-centered education:

“The increasing student population and its growing diversity presents challenges to the traditional methods of teaching and learning, making it necessary to adapt the classroom to focus on the diversity of students' experiences, engage with many different types of learners and inspire students through a mutual learning experience.” (ibid. p. 1)

According to this report (ibid. 2015), student-centered learning has 9 fundamental principles, as in the following (here slightly re-ordered, for clarity and logicity):

1. Student-centered learning requires an on-going reflexive process
2. Student-centered learning does not have a “One-Size-Fits-All” solution
3. Students have different learning styles
4. Students have different needs and interests
5. Students have different experiences and background knowledge

6. Choice is central to effective learning in student-centered learning
7. Students should have control over their learning
8. Student-centered learning is about enabling, not telling

3.2 Learning needs cooperation between students and staff

It is interesting to go into some further detail regarding a few of these, and to try and make clear a pattern. The first two principles could perhaps also be summarized as expressing non-staticness, in that they state that there is no one fixed style of teaching that can be applicable always. In accordance with this, Todorovski et al. (2015) state that the “philosophy of SCL is such that teachers, students and institutions need to continuously reflect on their teaching, learning and infrastructural systems” (ibid. p. 5) in order to “continuously improve the learning experience of students and ensure that the intended learning outcomes of a given course or program component are achieved in a way that stimulates learners' critical thinking and transferable skills.” (ibid. pp. 5–6) Moreover, they claim that a “key concept underlying SCL is the realization that all [educational institutions] are different, all teachers are different, and all students are different.” This connects to the third and fourth principle, so that perhaps principles 2–5 could be summarized by the slogan of individualization and adaptiveness. A third over-arching theme, clearly visible in principles 6–9 is that of cooperation and distributed power, since these principles dictate that students should be in much more control of their learning environment than what is typical in traditional education.

Gover et al. (2019) state that “A teaching environment geared towards student learning is one in which the teacher facilitates the student’s learning. Learning is a responsibility shared between the two [...] and is achieved, for example, through methods such as problem- or research-based learning.” As we shall see below, this connects **student-centered education** both to the concept of **inquiry-based learning** and to the pedagogical approach of **dialogic education**.

As is evident by this introductory text, what is called student-centered learning is a family of pedagogical approaches, and may include quite different pedagogies and didactical models, some with different focus than others and with different outcomes and effects on student learning and development.

3.2.1 The teacher-centered approach

In order to better understand and define a **student-centered teaching and education approach**, it is fruitful to look into a contrasting pedagogical approach, namely the teacher-centered approach to teaching and education. In a teacher-centered approach, the teacher does most of the talking, the teacher determines the aim of the lessons, its content, and its pedagogical setup both on the macro-, meso- and micro-levels. That is, he/she plans a lesson, perhaps gives a lecture, assigns preparatory tasks (incl. reading), determines what questions should be asked and who is to answer them (perhaps oftentimes the teacher himself/herself).

Of course, in the teacher-centered approach, the teacher might have the learning of his/her students in mind (hopefully), but it is still his/her idea about both what and how they shall learn, that is the main determinant of the pedagogical outcomes in the classroom.

Moreover, in the teacher-centered approach to teaching and education, there tends to be a one-size-fits-all approach, in that the teacher teaches to a whole group of individuals, typically a class, which means that all students more or less get the same experience, the same

content presented to them, at the same time, in the same way. The classical lecture is a typical example of this approach to teaching.

3.2.2 Strengths of the student-centered approach

There are several positive features of student-centered teaching and education, of which we will here detail a few. Gover et al. (2019) summarize some of the strengths as follows: “Many benefits have been linked to student-centered learning. It is generally considered to improve teaching [...] and student learning. It fosters transversal skills, critical thinking, and active citizenship, and is thus considered to better prepare students for the current and future labour market and society. For example, links have recently been suggested between student-centered learning and the achievement of the United Nations’ Sustainable Development Goals (SDGs) [...]” (ibid. p. 6).

Student interest. One of the strengths of student-centered teaching and education is that it holds promise to contribute to student engagement with school, the school subject at hand and the specific learning content that is currently being focused on, in comparison with a teacher-centered approach. This is quite likely to be the case, to differing degrees, whatever form of student-centered approach to education that is being taken.

Citizenship education. It has been claimed that a student-centered approach to education is a good means of fostering active citizenship, and for “the current and future labour market” (ibid. p. 6).

Communication development. Through students being more active in a student-centered approach to education than what is typical of a teacher-centric approach to education. At least as long as the approach taken is a collaborative one, it is a likely outcome, although also between different versions of collaborative approaches, effectiveness might vary.

Thinking skills. It is stated, by e.g., Todorovski et al. (2015), that student-centered learning aims to develop thinking skills among participating students, such as critical. Effectiveness depends on version of student-centered approach taken. As we shall see below, some forms of student-centered learning have strong effects in this field.

Problem solving. One of the thinking skills that is mentioned by e.g., Todorovski et al. (2015), that student-centered learning aims to develop, problem-solving. Effectiveness depends on version of student-centered approach taken.

Creativity. It is stated, by e.g., Todorovski et al. (2015), that student-centered learning aims to develop thinking skills among participating students. Effectiveness depends on version of student-centered approach taken.

Responsibility and independence. Another positive outcome of student-centered education is supposed to be that the students develop independence and responsibility. For example, Todorovski et al. (ibid. p. 1) state that high quality “higher education equips the world with active, responsible citizens, ready to take on tomorrow’s challenges, and student-centered learning is essential in ensuring this.” As compared to teacher-centric approaches, this is a likely outcome, but again, effect sizes will reasonably vary with what version of student-centered approach to education that is taken.

3.2.3 Challenges to the student-centered approach

But while there are strengths with a student-centered approach to education, there are also some challenges and possible weaknesses.

Demanding of students. A student-centered approach to education demands that students are active participants in the educational situation, making choices, suggesting learning

activities, collaborating with each other, and engaging in research- or problem-based activities, or, in other words, in joint inquiry. This might be challenging for students, demanding engagement with loads of factual information, with collaborating with others (if such a version of student-centered education is taken), and with being essential drivers of the learning activities themselves, among other things.

Demanding of teachers. In a student-centered approach to education, some workload is being moved from teacher preparation (e.g., preparing lectures) to the teacher having to actively engage in real-time with students in the learning activity, oftentimes leading the activity, providing feedback, facilitating, and ensuring high quality in the pedagogical activities. This might put a high cognitive demand on the teacher, demand flexibility and reflexivity, as well as be experienced as frightening for teachers.

3.2.4 AI technology and the student-centered approach

AI-based technology, if properly designed and implemented, might be used to overcome some of the challenges and drawbacks of a student-centered approach to education.

For example, students can be supported in their active work in a student-centered educational situation by an AI technology in several ways. One such way is that modern digital technology provide access to vast amounts of information. But there is the problem of gathering, sorting and compiling information found online. Tools incorporating AI technology, such as the Study Buddy, can provide much valuable support for the student in this matter. When a new question or factual statement arises in a student-centered educational setting, the student can use the Study Buddy to check up on this information, or suggest further reading, questions to discuss, and so on. As such, a tool such as the Study Buddy can be continuously used by the student when they are working more independently of the teacher.

AI based technology can also provide support for the teacher in a more student-centered approach to education, also diminishing the otherwise possibly increasing pressure on the teacher of quickly adapting to new information or suggestions by the students, and so on. For example, if the students suggest a learning activity, the teacher might in absence of an AI based tool need to wait until after a specific class ends in order to plan and prepare the proposed learning activity. But, by using an AI tool such as the Teacher Mate, the teacher can within minutes of the proposition of a new learning activity have received tips for how to outline such an activity and thereby supporting the students in their learning in an effective way, such as by providing discussion questions or a set of tasks to be carried out in a project-based or problem-based learning activity – work that might otherwise take teachers many hours to plan.

4. Inquiry-based education and AI

In this chapter, we will address a pedagogical approach called inquiry-based education and connect this to AI technology in education.

4.1 What is inquiry-based education?

As is evident from the naming of this approach, an inquiry-based approach to education considers the process of inquiry an important educational activity. But what, more precisely, is educational inquiry? Oftentimes, the term is used in the context of a collaborative form of inquiry, in a methodology known as the community of inquiry. Burgh (2021) notes that as “a teaching method, the community of inquiry is a purposive activity of inquiry, experimentation and collaboration motivated by intelligent curiosity” (ibid. p. 13) that arises from a “sense of genuine doubt that signals a rupture in consciousness” (Gregory & Granger, 2012, p. 6), i.e., “an approach to education in the tradition of reflective education in which good thinking and its improvement is central.” (Burgh, 2021, p. 13) This term, community of inquiry, “has a long history that dates back to Charles Sanders Peirce, whose original formulation is grounded in the notion of communities of disciplinary-based inquiry engaged in the construction of knowledge.” (ibid. pp. 12–13). Another key figure in the history of philosophy of education that is connected to inquiry as a main educational activity is Dewey. (Gregory & Granger, 2012; Thornton et al., 2022). “However, its current usage as a productive pedagogy owes much to [Lipman and Sharp] (1978) who extensively developed the community of inquiry as an approach to teaching that transforms the structure of the classroom in fundamental ways.” (Burgh, 2021, p. 13).

Kizel (2021) contrasts on the one hand the community of inquiry as a pedagogical mode with on the other hand that of, borrowing a phrase from Freire, that of banking education, by which he means “a method of teaching and learning where students simply store the information relayed to them by the teacher” (ibid. p. 3). “In a ‘banking educational’ environment, the classroom is structured so as to encourage the student to remember and accurately recall the information provided by the instructor” (ibid.). This, claims Kizel, leads to a situation where “teachers take pains to ensure that students believe that texts rather than thinking—and certainly not independent thought—are the most important part of education” (ibid.). Contrastingly, an inquiry-based approach to education “situates learning in a space of questions rather than in a corpus of answers, promoting a community that facilitates a form of thinking and learning” (ibid. p. 4) that is open, democratic, and liberating, thereby constituting “a pedagogy of searching [b]ased on a pursuit of meaning that facilitates personal development” (ibid. p. 5).

As we saw above, Gover et al. (2019) stated that appropriate for student-centered learning was pedagogical “methods such as problem- or research-based learning.” This shows one of the connections between student-centered learning and inquiry-based learning since an overarching principle behind both problem-based and research-based learning can be said to be inquiry. Basing a lesson around a problem that students should work to solve can be said to be to invite them to enter into a kind of inquiry, one aimed specifically at solving the problem at hand. Similarly, doing research is doing inquiry into a subject, arguably oftentimes a bit more openly and freely than in the case of a problem-based learning approach – but the role of inquiry is nonetheless essentially present in both cases.

4.2 Strengths of inquiry-based education

Let us now turn to a few strengths with an inquiry-based approach to education. In fact, more strengths will be covered in, and there will be some overlap between this chapter and, the chapter on dialogic education below, since, as will be evident below, the two are also closely connected since important versions of dialogic education are also inquiry-based pedagogies.

Democracy development. One of the strengths of the inquiry-based approach to education is its alleged development of democratic abilities and tendencies among the students. For example, Burgh (2021) states that in an educational context, what he calls the social dimension of democracy is the most important, by which he means “democracy as primarily a process; as a way of being, a way of thinking and communicating on important life-matters, and as an associated [form] of living that is inherently inclusive but requiring the cooperation of others” (ibid. p. 12). Moreover, he claims that what connects both the social and the political side of democracy is that “democracy is a form of inquiry” (ibid.). This, he concludes, means that our “task as educators in a democracy is to develop the skills, capacities, and dispositions to facilitate the kinds of relationships that support democratic ways of life” and that because “learning to think is at the core of educational aims and practices”, this entails that school needs to “facilitate the development of these skills, capacities, and dispositions necessary to both living in and thinking about democracy.” (ibid.) It is in this context that he refers to “the potential of philosophical inquiry as an effective educational strategy for enhancing democratic ways of life” (Burgh, 2021), a view put forth by UNESCO (2007) and others (e.g., Motherway, 2020; Venter & Higgs, 2014).

A vehicle for change. Several authors see the inquiry-based approach to education as a means, in some cases a necessary ingredient (e.g., Thornton et al., 2022), in a school that help students acquire the skills, abilities and dispositions needed to purposefully and responsibly driving change and dealing rationally with the choices of a future (Burgh, 2021). Not the least in relation to the profound changes that we are currently facing, this is interesting in relation to AI in education.

Scientific thinking. As noted above, a central feature of scientific work is that it is inquiry-based – indeed, oftentimes the expression “scientific inquiry” is often synonymous with the expressions “scientific method”, “scientific process” or “scientific work”. Hence, letting students engage in inquiry-based learning is by many seen as a good way of introducing students into scientific thinking, in understanding science and scientific work – skills not only needed for those who will eventually be actively involved in scientific work themselves someday, but essential skills and understandings for any citizen of the 21st century.

Cognitive development. As will be evident below, a well-carried out inquiry-based education will, according to a vast body of scientific evidence, help participating students develop cognitive abilities (e.g., Trickey & Topping, 2004; Topping & Trickey, 2007a; García-Moriyón et al., 2005) This, in turn, is helpful for students in many ways, contributing, among other things, to an increased ability in other school activities.

Creative thinking and problem-solving. Participating in inquiry on a topic is not a static, easily predetermined process, but instead a process demanding experimenting, changing, making choices, evaluating and re-adjusting, suggesting possible explanations and possible tests, and so on. Hence, it involves creative thinking and problem solving, and in turn holds promise to develop these skills in participating students. This is also what studies on e.g., philosophical inquiries in the so-called Community of Inquiry approach show (e.g., Bowyer et al., 2022; Kizel, 2022; Trickey & Topping, 2004).

Interest. Engaging in inquiry on a subject is an active way of learning, that holds promise to engage and stimulate students and lead to a growing interest in the educational activities, as compared to orthodox forms of education.

4.3 Challenges to inquiry-based education

Let us now turn to some challenges that inquiry-based education might face. We shall see below that similar challenges arise for dialogic education, which is no surprise, since these pedagogical approaches are connected in several ways, the dialogue being an important forum for educational inquiry, and collaborative inquiry being an important part of a well-functioning educational dialog.

Overcoming personal biases. In order to lead an effective educational inquiry, a teacher must, according to Kizel (2021), be able to “free themselves from assumptions and closed-mindedness”. This is not always an easy task, and the teacher might need tools to support him/her on this journey.

Seeing different perspectives. This challenge is related to the one raised above. A high-quality inquiry cannot only follow in one track, seeing things from one perspective. An inquiry consists in following the evidence where it leads us, in challenging assumptions, in trying different perspectives, solutions, theories and explanations – if so, only for the sake of the inquiry. This is especially important for a teacher, as he/she might be the leader of an inquiry, or in other ways acting as a support for students in their inquiry. Indeed, Sowe & Lockrobin (2020, p. 35) has claimed that “[o]ne of the benefits of using the Col model [...] lies in participants coming to see issues from more than one perspective.” But doing all of this might be challenging, and it requires training, methods, or support tools (or a mix thereof).

Training needs. One challenge for inquiry-based learning is that it requires some training for teachers, since, as noted by Kizel (2021, p. 3), “the majority of schoolteachers serve as agents of the ‘banking education’ system”, and as such are not used to inquiry as a main educational activity. This means that many teachers have little experience to draw from, both from their own teaching practice and from those of their own teachers. This is a major hindrance for inquiry-based teaching to be realized.

Fear of losing control. Just as with dialogic education, as discussed below, many teachers are afraid of losing control of the classroom as a consequence of adopting student-centered, inquiry-based, or dialogic education.

Fact-checking on the fly. In an inquiry-based educational activity, it is difficult to determine on beforehand exactly what content will be dealt with. A teacher might decide a starting point for an inquiry, such as a problem, a question, an issue – but it lies in the nature of an inquiry that it is free and that it might lead to places that the participants did not anticipate at the onset. As such, it is oftentimes difficult to predict and fully plan a lesson, since the joint inquiry might lead the group to new topics or new aspects of a question. As a result, many different factual questions might be raised. One of the worries sometimes raised by teachers are that in inquiry-based education, it is therefore more difficult to know in beforehand which topics and themes that will be touched upon, and therefore what specific parts of the subject-knowledge and factual information that might be relevant. Since students might ask question or claim things, that means that it would be beneficial to be able to fact-check in real time. Therefore, some teachers raise fears that they will end up in situations where students ask questions are claim things that they will not be able to readily answer to. Since planning and reading up before the class therefore become more difficult, teachers need to be able to fact-check very quickly, either by having a vast knowledge or by acquiring trustworthy information quickly from some external source.

Fear of conflict. Another potential problem facing the teacher concerning a dialogic education situation is the fear that conflicts might arise. For example, if a teacher prepares that the class shall be discussing on some current topic from the news, he/she might fear that the students will suggest or choose a topic on which there are strong disagreement in the group, and that the following talk might lead to conflicts between students in different “camps”. This issue is raised for example by Thornton et al. (2021) and Kizel (2021).

4.4 AI technology and inquiry-based education

Let us now turn to how AI technology can support dialogic education, in both potentially overcoming or diminishing some of the potential challenges or drawbacks with dialogic education, but also perhaps through providing new opportunities for dialogic elements in school.

Overcoming personal biases. While it might be very difficult to, and require a lot of training to, even partly overcome personal biases (many would argue that it is possible for a human being to do so completely), and “free [oneself] from assumptions and closed-mindedness”, there might actually be possible help from AI tools. While some claim that there is a risk that AI just replicates and fortifies biases and prejudices, others claim that AI can actually go beyond the kind of biases that we as humans typically display. Thus, it might be possible that a well-designed AI tool can help a teacher to overcome personal biases, by e.g., suggesting perspectives, ideas, questions, or arguments that he/she himself/herself fails to see. For example, when in a certain inquiry, a teacher could prompt an AI to suggest other perspectives than the one that he/she tells the AI that he/she has taken himself/herself.

Seeing different perspectives. Just as this challenge is related to the one raised above, so are the possible ways in which AI technology can help mitigate this problem. As noted before, it might be possible that a well-designed AI tool can help a teacher to become aware of different, and overlooked, perspectives, ideas, questions, or arguments. For example, when in a certain inquiry, a teacher could prompt an AI to suggest other perspectives than the one that he/she tells the AI that he/she has taken himself/herself. Of course, just being presented with a different possible perspective does not mean that a teacher will be able to appropriately deal with it in the context of an educational inquiry. Some training and certain dispositions and skills from the teacher will be needed, but a well-designed AI tool can provide helpful support making the process less demanding for the teacher.

Training needs. As noted above, a challenge for inquiry-based education is the need for training of teachers. While an AI might not, at least not in the first place and at least as long as it is not used to substitute, but rather to complement, the teacher, be able to fully remove the need of teacher training, it might reduce the amount of training that is needed. Part of this has to do with several of the other problems that was dealt with above and those what will be dealt with below, but on top of that, an AI might be developed in order to support a facilitator by suggesting relevant and effective teacher moves (cf. Glina, 2012), or prompts, to use in a dialogue, in order to further its quality.

Fear of losing control. While both a dialogic education approach, an inquiry-based approach, and a student-centered approach partly all consist of the ideal that some of the control that is typically held by a teacher in the traditional, monologic, and teacher-centered approaches to education, this does not have to mean that the teacher totally loses control of the situation. To the contrary, in all of these, a good teacher facilitates the learning situation, supports his/her students, and acts as a leader in the classroom. But this is demanding of the teacher. To some extent, a well-designed AI tool might support teachers in such endeavors. For example, by providing him/her with fast and (hopefully) reliable factual information (at least within certain domains), an AI based tool can provide information to the teacher that helps him/her facilitate the dialog more effectively. Moreover, since a tool such as the Teacher Mate can help by e.g., proposing discussion questions, the teacher have a lifeline to revert to in cases where he/she does not himself/herself quickly come up with questions to ask the

students in order to help facilitate the dialog to high levels of quality. These are just some of the ways in which a teacher might be supported by an AI tool in a way that means that there is a lesser need for fear of losing control (to a too large degree) in student-centered, inquiry-based, and dialogic educational situations.

Fact-checking on the fly. The problem of need to fact-check quickly can of course be alleviated using modern digital technology. The readily available vast amount of knowledge online means that teachers do not need to have all information stored either inside their memory or in books in the classroom. But there is the problem of gathering, sorting and compiling information found online. Tools incorporating AI technology, such as the Study Buddy and the Teacher Mate, can provide much valuable support in this matter. When a new question or factual statement arises in an educational inquiry, and the group, teacher, or any of the students, want to check up on factual information quickly, this can be supported by an AI tool.

5. Dialogic education and AI

This chapter deals with a form of education, or rather a family of approaches to education, which is known as dialogic education. As we shall see, there are several forms of dialogic education, and some of them share close connections to what has been discussed above, since they are both student-centered and inquiry based. Hence, this chapter adds further to what has been discussed above.

5.1 What is dialogic education?

In order to understand *dialogic* education, it is fruitful to contrast it with *monologic* (also known as teacher-centric, or traditional) education (or teaching). (Gardelli, 2016) This is similar to how we above contrasted student-centered education with teacher-centered education, or inquiry-based education with ‘banking education’, and the lines of conflict are related and similar.

While there are many critics of the traditional model of classroom talk (e.g., Alexander, 2008), such monologic teaching is still dominant in school (Gardelli, 2016; Nystrand et al., 2003; Reznitskaya et al., 2012), with teacher instruction being used as the main didactical tool. Nonetheless, dialogue “as a communication form consistent with the pluralistic ideals of a democratic society, has long been embraced by educators concerned with empowering their students to become independent thinkers and active citizens” (Reznitskaya et al., 2009, p. 29). For example, Dewey (e.g., 1916), Vygotsky (e.g., 1968) and Lipman (e.g., Lipman, Sharp, & Oscanyan, 1980) are seen as early proponents of the dialogue as a pedagogical foundation (Reznitskaya et al., 2009). In the context of AI and education, it is interesting to investigate whether a student engaging with an AI tool can be seen as an example of a dialogue, and if so, to what extent. These matters will be returned to below.

As noted above, there are different possible ways to instantiate dialogic education, and this text will therefore sometimes take a didactical approach known as Philosophy with Children (PwC) as a concrete example, since this is both a highly dialogical pedagogical approach, and one that is well-researched and has been supported by a lot of evidence of its effectiveness (Gardelli, 2016; Kizel, 2022; Trickey & Topping, 2004; UNESCO, 2007), and also a form of dialogic education which is both student-centered and inquiry-based. One form of PwC is the Philosophy for Children program (P4C), indeed the historically primary one, and sometimes the wider family of approaches is therefore called Philosophy for/with Children (P4wC).

Dialogic teaching is generally characterized by a non-traditional power distribution in the classroom, in which all participants (i.e., both students and teachers) “meet on terms of equality” (Reznitskaya et al., 2012, p. 288) and where teachers “treat students as potential sources of knowledge and opinion, and in so doing complicate expert-novice hierarchies” (Nystrand et al., 2003, p. 140). In order to facilitate for this, dialogic classrooms also feature

open and authentic questions; i.e., questions to which the teacher often does not have a ready-made answer (Alexander, 2008), and that “serve to inspire meaningful inquiry into new understandings” (Reznitskaya et al., 2012, p. 288). This connects dialogic education to the inquiry-based educational strategies discussed above – and indeed, a P4wC approach is oftentimes referred to as a Community of Inquiry (CoI) approach. Genuine and open questions also help support the egalitarian character of the discussion – because in a case where one party has all the answers, the possibility of a genuine dialogue can be questioned, and it can also be questioned to what extent such a situation can be considered egalitarian.

Another central feature of dialogic classrooms is the frequent meta-level talk and reflection, in which participants examine the educational process and the outcomes of the dialogue, in order to further the quality of it (Lipman et al., 1980).

One characterization of dialogic education was given by Alexander (2016), in:

“[D]ialogic teaching harnesses the power of talk to stimulate and extend students’ thinking and advance their learning and understanding. It helps the teacher more precisely to diagnose students’ needs, frame their learning tasks and assess their progress. It empowers the student for lifelong learning and active citizenship. Dialogic teaching is not just any talk. It is as distinct from the question-answer and listen-tell routines of traditional teaching as it is from the casual conversation of informal discussion.” (Alexander, 2016)

In conjunction with the above description of dialogic education, Alexander also gave the following characterization of some of the requirements for a genuine dialogic education to be able to take place:

interactions which encourage students to think, and to think in different ways; questions which invite much more than simple recall; answers which are justified, followed up and built upon rather than merely received; feedback which informs and leads thinking forward as well as encourages; contributions which are extended rather than fragmented; exchanges which chain together into coherent and deepening lines of enquiry; discussion and argumentation which probe and challenge rather than unquestioningly accept; professional engagement with subject matter which liberates classroom discourse from the safe and conventional; classroom organisation, climate and relationships which make all this possible. (Alexander, 2016)

But while dialogic education focuses on open dialogue as the driver of the learning activity, which invites and encourages students to think and reason for themselves, monologic teaching typically involves another communication pattern, recitation (Alexander, 2008), with “closed teacher questions, brief recall answers and minimal feedback that requires children to report someone else’s thinking rather than to think for themselves, and to be judged on their accuracy or compliance in doing so” (Alexander, 2008, p. 93). Nystrand et al. (1997, p. 6) state that “[w]hen recitation starts, remembering and guessing supplant thinking.” This communication pattern, typical of monologic education, is commonly called “Initiation–Response–Feedback” (IRF) (e.g., Alexander, 2008) or “Initiation–Response–Evaluation” (IRE) (cf. Backman et al., 2021b).

Going back to the above discussion of student-centered education, we can see from the definitions and descriptions of dialogic education that most genuine and high-quality dialogic education is highly and thoroughly student-centered. This is, for example, clearly the case with the didactical method of philosophical dialogs, which is a clearly student-centered form

of dialogic education. It is also worth noting that much dialogic education, in particular philosophical dialogs, is inquiry-based or inquiry-driven. This is also evident in the fact that this methodology is oftentimes also referred to as a community of inquiry (CoI) approach to education (see e.g., Burgh, 2021; Gardelli et al., 2012; Lipman, 2003). These connections to student centered and inquiry-based teaching and education means that it is likely to assume that the many benefits of these will also be present in dialogic education, which is the topic we will return to below.

5.2 Strengths of dialogic education

Numerous studies have investigated the effects of dialogic education on several aspects of students' learning and development. Large-scale meta-syntheses have reported good effects of dialogic education in general (Hattie & Zierer, 2019). For example, Hattie (RRR) has stated that increasing the amount of dialogic teaching in the classroom are among the ten most important changes to increase student performance.

One of the more thoroughly investigated forms of dialogic education, which has also shown strong results in several quite different areas, is a didactical method called Philosophy for Children or Philosophy with Children, oftentimes abbreviated as P4C (e.g., Gorard et al., 2017) and PwC (e.g., Gardelli et al., 2012; RRR), and recently jointly as P4wC (e.g., Kizel, 2022).

P4wC is considered to be “substantiated by a record of published, peer-reviewed research” (Murphy et al. 2009, p. 760) since the “quality and quantity of evidence [is strong in] comparison with that on many other methods in education” (Trickey & Topping, 2004, p. 374). Several meta-studies and meta-analyses support the effectiveness of P4wC regarding students' development in several areas relevant for increased and improved communicative participation, such as greater amount and improved quality of student talk, reasoning, and argumentation (García Moriyón, Rebollo & Colom, 2005; Murphy et al. 2009; Trickey & Topping, 2004, Yan et al., 2018). Interestingly, it has broad and far-reaching effects, both within cognitive domains and other domains (Topping & Trickey, 2007a; 2007b).

It has been shown that these kinds of dialogic education can be a means to inclusive education, and that participants from what by many would be considered very disadvantaged and challenging groups can successfully participate and develop from participation in the dialogic education (e.g., Backman et al., 2020, 2021; Gardelli et al., 2023), in particular with the use of technological tools (Backman et al., 2021, 2022b).

Democracy development. One of the often-cited reason in favor of a dialogic education, specifically in the form of philosophical dialogs, is its ability and tendency to promote democracy (e.g., Burgh, 2014; Cam, 2009, Di Masi & Santi, 2014; Gardelli et al., 2014).

Social benefits. Among the strengths of dialogic education are the many social benefits that is has been found to produce and support. For example, it has been found that in dialogic education, students show a larger engagement with other students' reasoning (Reznitskaya et al., 2012; Topping & Trickey, 2007b) and that participation in dialogic education strengthens the students' interpersonal relationships (Trickey & Topping, 2004) and promotes pro-social behavior (Colom et al., 2005).

Emotional development. It has been found that participating in dialogic education, in particular in P4wC based educational interventions, are a good means of helping students develop emotional skills and of achieving other positive effects in the emotional domain, such as promoting gains in self-esteem (Gorard et al., 2015; Trickey & Topping, 2006), pro-social behavior (Colom et al., 2005), emotional self-awareness and emotional intelligence (Trickey & Topping, 2004; 2006).

Communicative benefits. Meta-analyses have repeatedly found support for the effectiveness of dialogic education with regard to students' development in several areas relevant for increased and improved communicative participation, such as greater amount and improved

quality of student talk, reasoning, and argumentation (García Moriyón et al., 2005; Murphy et al., 2009; Trickey & Topping, 2006; Yan et al., 2018). Other areas in which improvements have been found are regarding students' confidence and willingness to speak (Gorard et al., 2015; Trickey & Topping, 2004), development of their listening skills (Gorard et al., 2015; Trickey & Topping, 2004), and increases in interactive behavior (Topping & Trickey, 2007a, 2007b). It has also been found that it leads to large qualitative and quantitative gains in group argumentation among persons with ABI and aphasia (Backman et al., 2020).

Cognitive benefits. It has also been shown that participation in dialogic education in the form of P4wC leads to developments in several cognitive skills and abilities (Trickey & Topping, 2004), both verbal and non-verbal (Topping & Trickey, 2007a), including logical and critical thinking (García-Moriyón, Rebollo, & Colom, 2005; Topping & Trickey, 2007a; 2007b), reasoning, justification and argumentation (Malmhester & Ohlsson, 1999; Topping & Trickey, 2007b). It has been shown to result in increased intelligence, over what some theorists call several domains of intelligence, significantly large gains in overall measured cognitive abilities, and IQ (Barrow, 2010; Topping & Trickey, 2007a). It has also been shown to have positive effects upon creative thinking (Trickey & Topping, 2004).

Critical thinking. While critical thinking can be said to be a cognitive benefit, and which should perhaps therefore sort under the above, it is worth highlighting specifically the benefits to critical thinking that results from a well-carried out dialogic education, such as the P4wC approach. Several studies have shown and confirmed benefits for participants critical thinking (e.g., Backman et al., 2020; García-Moriyón, Rebollo, & Colom, 2005; Malmhester & Ohlsson, 1999; Topping & Trickey, 2007a; 2007b; Trickey & Topping, 2004). Since this is such a vital skill for students, especially in the 21st century, this is important to note and highlight. As we shall see below, there is also a fear among some of the participants in the workshops that the increasing use of AI technology might bring with it a lowering of students' development of critical thinking skills, and considering this, it is especially important to highlight these effects of dialogic education in the context of AI education.

Creative thinking and problem solving. While creative thinking can be considered a cognitive skill, the skill or ability of problem solving is perhaps more than just a cognitive skill in the narrow sense, also including a disposition to engage in trying to solve problems and perhaps also such emotional elements as a degree of self-confidence in one's own ability to successfully deal with and solve problems. Interestingly, participation in philosophical dialogs (and similarly can be assumed to be the case, at least to some degree, for other forms of dialogic education as well) has shown to develop all of these, both the more purely cognitive aspects of creative thinking (Bowyer et al., 2012; Trickey & Topping, 2004), the disposition to engage with problem-solving and persistence in thinking (Bowyer et al., 2012; Trickey & Topping, 2004) oftentimes needed for problem-solving, and self-confidence in oneself as a thinker (Gorard et al., 2015; Trickey & Topping, 2004; 2006).

School performance increases. It has been shown that participating in P4wC education improves school performance, especially for students that are considered "disadvantaged" (Gorard et al., 2017). Studies have found that it has several benefits on students' skills, including reading (Murriss, 2014; Nystrand et al., 2003; Trickey & Topping, 2004), text comprehension (Alexander, 2008; Reznitskaya et al., 2012), and argumentative writing (Reznitskaya et al., 2012), as well as math and quantitative reasoning (Topping & Trickey, 2007a; Trickey & Topping, 2004). It has also been found to have a positive impact on students' enjoyment and interest in key educational activities such as reading and discussion (Reznitskaya & Glina, 2013). Not surprisingly, studies have repeatedly reported that participation in P4wC positively increases academic achievement (Fisher, 2001; Gorard et al., 2015; Murriss, 2014; Topping & Trickey, 2007a; 2007b).

5.3 Challenges to dialogic education

Dialogic education also faces several challenges, which might be part of an explanation for why it up till now has seen so little adoption in classrooms, even though theorists and researchers have for a long time advocated it for its many strengths.

Training needs. One challenge is that it requires some training for teachers to become good facilitators of philosophical dialogues. Not the least is this because, as noted above, a majority of classroom practice has been found to be monological, which means that teachers have little experience to draw from, both from their own teaching practice and from those of their own teachers, as regards how to successfully act as a facilitator in dialogic education. In the words of Schaffalitzky (2021, p. 1), it is “well-known that it can be a challenge for teachers to make the transition from the traditional teacher role to that of the facilitator.”

And unfortunately, bad facilitation quite often leads to bad dialogues, which means that many of the good effects described above likely will be absent, and that even some harms might be done, if not from anything else, from lack of the other educational activities that could have been carried out instead of the failed dialogue.

Experienced time-restraints. While dialogic education is repeatedly found to bring about many important good effects in school, there are still many tasks that a teacher is responsible for carrying out, and many teachers report struggling with finding time to carry out dialogic education. While this might in the end be a misguided fear, since engaging the students in a dialogic educational activity might in fact more than well meet the specific goals that the teacher might believe hinders him/her from engaging in dialogic education, it is still worry that is repeatedly raised and felt by teachers wanting to increase the amount of dialogue in their classroom.

Fear of losing control. When providing professional development interventions to teachers, such as in-service teacher training courses at the university or when leading workshops in school on the topic of developing dialogic educational skills among teachers, one topic that oftentimes are being raised by teachers are their fear of losing control of the classroom, if leaving a teacher-centric monologic form of educational setup. Similar findings have been reported in the research literature as well. For example, Fair et al. (2015, p. 34) noted that some teachers feared “a lack of control in the classroom”. One of the teachers in their study put this into words in saying that he/she “likes things to be very structured in the classroom and was not comfortable with students in control and having to develop their own opinions”.

Cognitive demands in facilitating dialogs. In dialogic education, some workload is being moved from preparation (e.g., preparing lectures) to active engagement in real-time during the dialogic learning activity. This might put a high cognitive demand on the teacher as facilitator, both to listen to and understand everything that is being said, make connections between statements, contribute to clarifications, and so on, to lead the dialogue towards high quality. Many of these things can be done collectively together with the students, but the teacher still has a special role and responsibility as the facilitator.

Fact-checking on the fly. the free and unrestricted nature of dialogic educational activities, due to the focus on joint inquiry and collaborative co-creation, means that these activities are oftentimes difficult to predict and fully plan for, since the joint inquiry might lead the group to new topics or new aspects of a question. As part of this, many different factual questions might be raised. Connected to this, one of the worries sometimes raised by teachers are that in student-centered and dialogic education, it is therefore more difficult to know in beforehand which topics and themes that will be touched upon in a specific educational activity, and therefore what specific parts of the subject-knowledge and factual information that might be relevant. Since students might ask question or claim things, that means that it would be beneficial to be able to fact-check in real time. Therefore, some teachers raise fears that they will end up in situations where students ask questions are claim things that they will not be able to readily answer to. Since planning and reading up before the class therefore

become more difficult, teachers need to be able to fact-check very quickly, either by having a vast knowledge or by acquiring trustworthy information quickly from some external source.

Fear of conflict. Another potential problem facing the teacher concerning a dialogic education situation is the fear that conflicts might arise. For example, if a teacher prepares that the class shall be discussing on some current topic from the news, he/she might fear that the students will suggest or choose a topic on which there are strong disagreement in the group, and that the following talk might lead to conflicts between students in different “camps”.

The need for engaged teachers. Several studies have found that for dialogic education to reach at least its full potential, there is a need for teachers that are engaged and motivated, as well as skilled as facilitators. For example, Fair et al. (2015) found that the level of engagement from the teachers strongly affected the outcome and effectiveness of an intervention based on a dialogical approach. Those teachers who did not feel comfortable with giving so much influence to the students, and therefore was not very positive to the intervention, did not go through with many sessions, and their students did not develop their skills compared to the control groups, while those teachers who was engaged with the method and therefore actually implemented dialogic teaching methods in several sessions also had students who developed considerably compared to the control.

5.4 AI technology and dialogic education

Let us now turn to how AI technology can support dialogic education, in both potentially overcoming or diminishing some of the potential challenges or drawbacks with dialogic education, but also perhaps through providing new opportunities for dialogic elements in school.

5.4.1 Overcoming challenges in dialogic education with AI?

Let us now turn to the issue of whether, and if so how, AI technology can help overcome the typical challenges faced in dialogic education, as detailed above.

Training needs. As noted above, one challenge, perhaps even a major challenge, for dialogic education is the need for training of teachers to become good facilitators of philosophical dialogues. While an AI might not, at least not in the first place and at least if it is not used to substitute, but rather to complement and support, the teacher, be able to fully remove the need of teacher training, it might reduce the amount of training that is needed. Part of this has to do with several of the other problems that will be dealt with below, but on top of that, an AI might be developed to support a facilitator by suggesting relevant and effective *teacher moves* (cf. RRR), or prompts, to use in a dialogue, in order to further its quality. An AI tool might also fulfil several other supportive roles in a dialog. For example, it might “listen” to the different statements by the students, and produce a map of the conversation, in line with work by Backman, Gardelli and Parnes (e.g., 2021).

Experienced time-restraints. As noted above, teachers often respond to learning about dialogic education that they think it seems like a very good thing, but that there is no time to implement dialogic teaching since there are so many other things to be done. As noted above, this objection is misguided, since it has been found that increasing dialogic elements in school does not in fact conflict with the goals that teachers need to reach, but in fact more effectively reaches many of these than the monologic education that teachers are traditionally engaging in. But increasing dialog by getting teachers to realize this might not be a feasible way. At least it is not the only way. In fact, AI technology might provide us with new opportunities for dialogic elements in school, by providing students the opportunity to engage in at least “dialog resembling” activities without the need of teacher engagement, through engaging dialogically with an AI tool directly. This will be returned to below. But AI technology might also help minimize the problem of time-constraints by an AI tool helping effective teacher work, minimizing teacher workload, and specifically helping in planning and supporting dialogic learning activities (such as proposing a lesson plan with a dialogic focus),

which make it easier for teachers to find time to include dialogic elements in their classrooms.

Fear of losing control. While both a dialogic education approach, an inquiry-based approach, and a student-centered approach partly all consist of the ideal that some of the control that is typically held by a teacher in the traditional, monologic and teacher-centered approaches to education, this does not have to mean that the teacher totally loses control of the situation. To the contrary, in all of these, a good teacher facilitates the learning situation, supports his/her students and acts as a leader in the classroom. But this is demanding of the teacher. To some extent, a well-designed AI tool might support teachers in such endeavors. For example, by providing him/her with fast and (hopefully) reliable factual information (at least within certain domains), an AI based tool can provide information to the teacher that helps him/her facilitate the dialog more effectively. Moreover, since a tool such as the Teacher Mate can help by e.g., proposing discussion questions, the teacher have a lifeline to revert to in cases where he/she does not himself/herself quickly come up with questions to ask the students to help facilitate the dialog to high levels of quality. These are just some of the ways in which a teacher might be supported by an AI tool in a way that means that there is a lesser need for fear of losing control (to a too large degree) in student-centered, inquiry-based, and dialogic educational situations.

Cognitive demands in facilitating dialogs. As noted above, in dialogic education some workload is being moved from teacher preparation (e.g., preparing slides and manuscripts for lectures) to active engagement in real-time during the dialogic learning activity together with the students. This might put a high cognitive demand on the teacher as facilitator, both requiring him/her to listen to and understand the things that are being said by the students, to make connections between different students' statements, to contribute by offering clarifications where needed, and so on, to lead the dialogue towards higher quality. Many of these things can be done in collaboration with the students, but the teacher stills holds a special role and responsibility since he/she is being the facilitator of the dialog. AI tools can help the teacher in several different ways here, both teacher-facing AI tools and student-facing AI tools, by offloading some of the tasks that the teacher otherwise needs to do, thereby lessening the cognitive demands of teachers, and thereby making dialogic education more accessible for more teachers. This is especially valuable for more inexperienced teachers, who might consider it a too big hurdle to get over to be able to start working collaboratively with his/her students in educational dialogs. The ways in which AI tools might be of utility here are many, some of which are discussed in relation to other challenges. In any case, these include the ability to fetch, structure and deliver information to the teacher or the students, the sorting or summarizing of information, and so on.

Fact-checking on the fly. The problem of need to fact-check quickly can of course be alleviated using modern digital technology. The readily available vast amount of knowledge online means that teachers do not need to have all information stored either inside their memory or in books in the classroom. But there is the problem of gathering, sorting and compiling information found online. Tools incorporating AI technology, such as the Study Buddy and the Teacher Mate, can provide much valuable support in this matter. When a new question or factual statement arises in a dialogic setting, and the group, teacher, or any of the students, want to check up on factual information quickly, this can be supported by an AI tool.

Fear of conflict. One of the ways to reduce the risk of conflict in dialogic settings – which is, to be frank, not very large anyways – is to incorporate rules of conduct into the method. But it might be somewhat difficult for the teacher to keep track of and highlight if any rules of conduct are broken, for at least two reasons. Both can potentially be minimized using the help of AI technology. The first is that it can be cognitively taxing to have yet another thing to keep observant about for a teacher facilitating dialogs, most notably for inexperienced facilitators. AI technology can help lighten this burden by aiding in identifying cases where the rules of conduct are broken. The second problem is that it might be difficult for a teacher

to point out, for social reasons. It might be a bit. Depending on the implementation of the AI technology (is it, for example, used in a chat environment, or as an aid in real-time verbal communication in a shared physical room?), the AI technology might either simply act as a gatekeeper censoring or blocking certain things from being posted (such as hateful or disrespectful utterances), or flag when such things are being said in a real-time verbal conversation. In this case, the possibility for an AI technology to be un-personal and insensitive might be an advantage. That is, it might not be held back by such things as it being uncomfortable for a human being to point out certain things, even though they ought to be pointed out.

So, even though this is not a particularly big problem in the first place, it is nonetheless meaningful to note that it can be even less of a problem with the aid of AI technology.

The need for engaged teachers. While in the long run, for a classroom to be deeply dialogic, there is still a need for engaged teachers, an AI technology might at least provide some relief for students lacking such teachers. That is, in case a teacher does not provide his/her students any chances for dialogic encounters, and AI technology might at least provide some chances for students to participate in dialogic (or quasi-dialogic – see more below) encounters.

5.4.2 Furthering strengths of dialogic education with AI?

Let us now turn to investigating whether, and how, an AI technology can help even furthering some of the strengths with dialogic education. We will not go through all the strengths covered above, and more than those could have been included as well, but we will instead investigate one of them below, as an example. Analogous reasoning could be carried out with respect to several of the other possible strengths as well.

Cognitive benefits. As noted above, it has also been shown that participation in dialogic education in the form of philosophical inquiry leads to developments in several cognitive skills and abilities. Parts of the explanations for this might be the engagements with big and complex questions and topics, stimulating new ideas that prompt participants to think in new ways and to employ a plethora of thinking skills and faculties to move the inquiry forward. Parts of these activities could perhaps be taken even further if the student had access to a well-designed AI tool, which could act as a further source of new, challenging ideas for the student to engage with, or prompts to take the students' thinking further, like suggestions for the student to propose a counter-example to some idea, to come up with a new perspective on a given topic, and so on. That said, there is also a risk that student off-loads some demanding tasks to an AI tool in a way that diminishes the positive benefits that otherwise could have been had. This could for example be through the student asking the AI to come up with counterexamples or new perspectives. Therefore, the key expression here is probably “well-designed”, so that the tool gives just enough, and the right kind of, support for the student, but does not come in the way of the student fully engaging with all his/her cognitive faculties in the inquiry.

5.4.3 Dialogic elements even in monologic teaching, through AI?

One possible strength with AI technology is that it might introduce dialogic elements even in an education that is otherwise monologic in its nature. This is particularly true of a tool such as the Study Buddy, which might let a single student by himself/herself introduce dialogic elements in an otherwise monologic teaching situation, by for example prompting the student in ways that a participant in a dialog would, or by allowing the student to have (at least) a kind of dialog (more on this below) with the tool.

Moreover, a group of students working collaboratively can use an AI tool to help make a group work session more dialogic, by using the AI tool as a discussion partner, for example through giving prompts to the AI tool to suggest discussion questions on a certain topic for them, or to provide an argument in favor of a view which the students themselves might have difficulties finding possible arguments in favor of, or against a view that all of them are finding themselves in agreement with, thereby broadening their perspectives and giving them new ways of thinking about an issue, and so on.

In this way, an AI tool might sidestep many of the problems that might otherwise face dialogic education, such as the need of teacher training or specific time allocated to dialogic activities, by bypassing the need for teacher engagement in the dialog.

5.4.4. Transitioning into dialogic education through AI?

Through the above-described mechanism, an AI tool like the Study Buddy might be a good first step towards dialogic education, because the teacher might introduce dialogic elements through letting the students use the Study Buddy, without leading to many of the difficulties with dialogic education like the need for teacher training. By this, many of the typical benefits with dialogic education (albeit not all of them) can be introduced almost without any of the challenges. Over time, the teacher might also more and more include dialogic elements in their teaching as well. In this process, a tool like the Teacher Mate can help the teacher making this transition, and a tool like the Study Buddy can support and stimulate the students into becoming more dialogical, as noted above.

5.4.5 Can a student have a dialogue with an AI?

Let us now turn to the question of whether a student can have a dialog with an AI technology, such as a “chat-bot” or educational robot or the like.

In order to answer this question, it is fruitful to think a little about what a dialog is and is not. One theorist that is sometimes invoked to shed light on the difference between dialogic and monologic communication is Bakhtin (e.g., 1984; 1986). Bakhtin claims that trying to make a clear-cut distinction between listener and speaker is incorrect, and that doing so would “produce[s] a completely distorted idea of the complex and multifaceted process of active speech communication.” (Bakhtin, 1986, p. 68) Moreover, he claims that:

[t]he fact is that when the listener perceives and understands the meaning (the language meaning) of speech, he simultaneously takes an active, responsive attitude toward it. He either agrees or disagrees with it (completely or partially), augments it, applies it, prepares for its execution, and so on. [...] Any understanding of live speech, a live utterance, is inherently responsive, although the degree of this activity varies extremely. Any understanding is imbued with response and necessarily elicits it in one form or another: the listener becomes the speaker. (Bakhtin, 1986, p. 68)

According to him, this response does not have to be immediate. To the contrary, it can also be a silent responsive understanding, at least primarily. This silence will sometimes come to an end, though, since “[s]ooner or later what is heard and actively understood will find its response in the subsequent speech or behaviour of the listener” (Bakhtin, 1986, p. 68). He concludes that:

all real and integral understanding is actively responsive [... and] the speaker himself is oriented precisely toward such an actively responsive understanding. He does not expect passive understanding that, so to speak, only duplicates his own idea in someone else's mind. Rather, he expects response, agreement, sympathy, objection, execution, and so forth [...] The desire to make one's speech understood is only an abstract aspect of the speaker's concrete and total speech plan. Moreover, any speaker is himself a respondent [... He is not] the first speaker, the one who disturbs the eternal silence of the universe. And he presupposes not only the existence of the language system he is using, but also the existence of preceding utterances – his own and others' – with which his given utterance enters into one kind of relation or another [...] Any utterance is a link in a very complexly organized chain of other utterances. (Bakhtin, 1986, p. 69)

The opposite of a dialog in his theory is a “nonproductive monologism” (Nystrand et al., 2003, p. 140), which Bakhtin considers a pathological form of communication, almost a form of communication disorder. Thus, in his view, dialogue, instead of claiming to have the “ready-made truth,” is seen as a (joint) seeking of truth (Bakhtin, 1984). Hence, for a teaching situation to be truly dialogical, it is impossible that one part has the view that he/she has the correct answer and is supposed to, no matter what, make sure that the other part is thus instructed. (Gardelli, 2016) A dialog has to be reciprocal and mutual.

On this view, whether a student can have a dialog with an AI or not depend, among other things, upon whether the AI can be said to fulfil the conditions of genuine reciprocity, a joint seeking of truth, genuine interest in the statements of the other, and so on. These questions will not be answered here.

Apart from a discussion about what a dialog is, it is fruitful to draw a distinction between genuine what we shall call a dialog and a quasi-dialog. Let us, for simplicity's sake, limit ourselves to cases including two participants in a “conversation”. In a genuine dialog, both participants meet the criteria of a dialog participant. In a quasi-dialog, though, at least one participant does not meet the criteria, but the conversation still has some resemblances of a dialog.

Among quasi-dialogs, though, some of them are experienced as quasi-dialogs, and some are not. Let us therefore also make a second distinction – by making two new definitions – that between what we will call an explicit quasi-dialog and a covert quasi-dialog, from the perspective of a certain participant, as detailed by the definitions below:

- (DEF) An explicit quasi-dialog is a conversation that is not experienced as a genuine dialog by the participant in question.
- (DEF) A covert quasi-dialog is a conversation that is a quasi-dialog but that is experienced to be a genuine dialog by the participant in question.

That is, a quasi-dialog is covert for a certain person if he does not realize that it is a quasi-dialog, but instead experiences it as a genuine dialog. The interesting question for us now is, whether for a certain educational situation to present all (or most) of the benefits to the participant that dialogic education has been found to have, it is necessary that the situation is strictly a genuine dialogic situation, or not. That is, might it suffice that it is a covert quasi-dialog, so long as the student in the situation is in the position of experiencing the situation as genuinely dialogic?

While many facilitators of philosophical dialogs surely treat the educational dialogs in such a way as to fulfil the criteria of a genuine dialog, it might very well be that some are just apt at adapting their behavior to mimic that of a genuine dialogic partner, while in fact not being one. That is, it might be that some of these situations are covert dialogs, as far as the students are concerned. In such a case, if the facilitator is effective at this modelling behavior, the students might feel as though they are participating in a genuine dialog, while in fact not doing so. It would seem like this might be sufficient for at least many of the benefits of dialogic education to materialize. For example, the students would engage in thinking long and hard about difficult issues, gaining cognitive challenge, and thereby training, getting new insights, and probably also feeling genuinely listened to, which would have many of the positive emotional and psychological effects shown above as a result.

Turning to an AI technology, therefore, we can investigate whether a student can have a covert quasi-dialog with an AI. The answer seems to be affirmative. Already with the technology available today, it seems quite likely that it might happen, and with the rapid technological advances that we are currently seeing, at least it will quite likely soon be the case. (We can notice the resemblance with the problem we are here discussing and the Turing test.)

Now, if a student is “conversing” with an AI and experiencing the situation as (at least closely enough resembling) a genuine dialog, that is, being in a covert quasi-dialog, the student might experience many of the benefits of engaging in dialogic education. For example, the student might receive feedback from an AI that challenges something the student has said and prompts the student to think more deeply about the issue, or to proposing further arguments, or drawing further distinctions. After all, many readers of well-written philosophy literature have over the centuries arguably experienced similar things from reading texts. If so, students could at least have close enough to a dialog with an AI tool as to gain many of the positive effects that we see resulting from dialogic education.

6. Scaffolding education and AI

In this chapter, we will address a pedagogical method known as scaffolding, and connect this to AI technology in education.

6.1 What is scaffolding in education?

In the construction profession, scaffolding refers to the temporary structures used to assist workers in the construction or renovation of buildings. In the field of education, “scaffolding” represents a pedagogical strategy that entails providing structured support and assistance to learners as they develop new knowledge, skills, or understanding of a concept (Maybin, Mercer, & Stierer, 1992). This support system is designed to help learners complete tasks that initially exceed their current capabilities. It is closely linked to Vygotsky’s Zone of Proximal Development (ZPD) concept (Wertsch, 1984), which describes the gap between what learners can achieve independently and what they can achieve with guidance and support from a more knowledgeable person, such as a teacher or peer (Hammond & Gibbons, 2005).

Scaffolding goes beyond being a simple form of assistance for learners in task completion; it encompasses distinct characteristics that set it apart from other support methods. In their research, Wood, Bruner, and Ross (1976) identified six key features of scaffolded assistance, each serving a specific purpose. These features include:

1. **Recruitment.** It involves focusing the learner’s attention and interest on a task.
2. **Reduction in degrees of freedom.** It entails simplifying a task by breaking it down into manageable components.

3. **Direction maintenance.** It addresses the maintenance of a task's goal.
4. **Marking critical features.** It refers to directing the learner's attention to essential and relevant elements.
5. **Frustration control.** It focuses on keeping a task at an appropriate level of difficulty.
6. **Demonstration.** It involves demonstrating and modelling successful performance.

Accordingly, in their study, Hammond and Gibbons (2005) introduced additional elements of scaffolding, including:

7. **Understanding extension:** addressing the ability of learners to utilize their acquired knowledge and skills to new situations.
8. **Temporary support:** highlighting the importance of a gradual withdrawal of scaffolding.
9. **Macro and micro focus:** stressing the importance of giving appropriate attention not only to learners needs but also to the tasks and their corresponding goals.

Later, in their review, van de Pol, Volman, & Beishuizen (2010) summarize scaffolding's characteristics in a conceptual model. The most notable aspect that sets scaffolding apart from other teaching methods is its dynamic and adaptable nature. This characteristic is referred to as "contingency" by van de Pol, Volman, & Beishuizen (2010). Unlike many forms of educational support, scaffolding doesn't adhere to a rigid structure; instead, it provides fluid support finely attuned to the learner's progress (Gonulal & Loewen, 2018). Specifically, a learner's progress must commence with a high degree of support and structure (Lin et al., 2012), ensuring that the given task aligns with their Zone of Proximal Development (Hammond & Gibbons, 2005). As learners develop the necessary skills and self-confidence to work independently, the scaffolding should be adjusted in accordance with their evolving needs. Failure to adapt the level of support may result in reduced motivation and boredom. This gradual reduction of scaffolding over time is known as "fading." Through this gradual fading and the transfer of responsibility to learners, scaffolding aims to foster the development of their abilities, enabling them to gradually become more independent (van de Pol, Volman, & Beishuizen, 2010).

6.1.1 Common Scaffolding techniques and tools

Although scaffolding has been regarded as a promising strategy for teaching and learning, operational definitions, specific designs, and introduction and withdrawal procedures appear not to be consistently agreed upon by researchers in science education (Lin et al., 2012; van de Pol, Volman, & Beishuizen, 2010). As a result, scaffolding remains an abstract concept and is not easily applied in practical classroom contexts, as previously highlighted by Maybin, Mercer, & Stierer (1992).

One reason for this might be that scaffolding can be used in different kinds of pedagogical situations, within quite different kinds of pedagogical approaches and didactical models. As such, it is interesting to note relations with scaffolding and the other approaches discussed in this text. For example, the role of the teacher as facilitator in dialogic education based on the P4wC model, is oftentimes said to be one that uses scaffolding. For example, Topping and Trickey (2007b, p. 76) described the method as being "scaffolded dialogue", since

"the teacher [is] encouraging pupils to: communicate their views in response to an agreed subject of 'enquiry', support their views with reasons, listen respectfully to views being expressed, indicate whether they agree or disagree with those views, provide alternative viewpoints, and gradually develop a process of dialogue (over a period of many months) that helps the

class construct a deeper understanding (or better solution) than would be possible individually” (Topping and Trickey, 2007b, p. 76).

Due to scaffolding’s dynamic nature, the support provided during scaffolding strongly depends on the characteristics of the situation (van de Pol, Volman, & Beishuizen, 2010). Therefore, scaffolding can be implemented in various ways. Prominent instructional scaffolding techniques include:

Feedback: Providing information on learners’ performance, helping them understand their strengths and areas for improvement. Feedback can be both formative (during learning) or summative (after an assignment or assessment).

Provision of hints: Offering hints and clues to guide learners’ attention or actions, helping them get started or guide them through a process.

Modeling: Providing learners with representative examples of what is expected of them, which give them concrete guidelines. The teacher or an expert may demonstrate how to perform a task or solve a problem, showing the thought process and steps involved.

Questioning: Asking learners questions that require active linguistic and cognitive responses. Asking questions stimulates learners’ thinking and guide their exploration of a topic. A special type of questioning encouraging learners to engage in a dialogue by asking probing questions, which fosters critical thinking and problem-solving is called Socratic questioning.

Bridging: Activating learners’ prior knowledge and building their skills by creating a connection between learners and the subject matter.

Schema building: Helping learners connect new information to already existing structures.

Collective scaffolding: In collective scaffolding learners work in pairs on a joint problem-solving task. In this way they can combine their mental capacities and produce better results together than they would have been able to do alone.

However, these techniques must adhere to scaffolding’s key aspects, namely contingency, fading, and the transfer of responsibility, to be successful (van de Pol, Volman, & Beishuizen, 2010).

To apply these techniques in real-life classroom contexts, several scaffolding tools must be employed. With the expanding availability and capabilities of various technologies, teachers can now implement scaffolding more efficiently (Falloon, 2017). Some of the most common tools used in scaffolding include:

Graphic Organizers: Tools like concept maps, mind maps, flowcharts, and diagrams help learners organize and visualize information, making complex concepts more understandable.

Interactive Simulation and virtual laboratories: Online or computer-based simulations allow learners to experiment with and explore scientific phenomena or complex processes in a controlled virtual environment. These platforms provide a digital space for learners to conduct experiments and practice laboratory skills when physical labs are not available.

Augmented Reality (AR) and Virtual Reality (VR): AR and VR technologies immerse learners in 3D environments that can replicate scientific concepts or historical events, enhancing the learning experience.

Adaptive Learning Systems: Educational technology platforms that use adaptive algorithms to personalize instruction based on each learner’s performance and needs.

Educational Apps: Mobile applications designed for learning often provide interactive exercises, quizzes, flashcards, and multimedia content for a more engaging learning experience.

Data Analysis Software: Computer tools (incl. specialized statistical software) assist learners in analyzing and interpreting scientific data.

Web-Based Tutorials and Videos: Websites and video platforms provide science tutorials and educational videos to explain complex concepts visually.

Online Collaborative Platforms: Tools for distance and both synchronous and asynchronous collaboration facilitate collaborative learning, allowing learners to work together on projects and share documents.

Peer Assessment Tools: Online systems that enable peer assessment and feedback, allowing learners to evaluate each other's work.

These scaffolding tools have been widely used to enhance teaching and learning in various subjects and educational contexts (Belland, et al., 2017). They help engage learners, provide additional resources, and support the acquisition of knowledge and skills.

6.1.2 Pedagogical implications

Scaffolding, as an educational concept and strategy, has found application in various educational settings and subject areas to support learners at different levels (Belland et al., 2017; Kim & Hannafin, 2011; Lin et al., 2012; van de Pol, Volman, & Beishuizen, 2010). It has been effectively utilized in the following common areas. Below are some of the most common areas where scaffolding has been applied:

Language Learning/ Literacy: Language education is a primary domain for frequent scaffolding application (van de Pol, Volman, & Beishuizen, 2010) to assist learners in developing their language skills. This can involve providing vocabulary support, using real-life examples, and engaging in conversations to enhance speaking and listening skills.

Mathematics: Scaffolding is employed to help learners understand mathematical concepts and solve math problems (Anghileri, 2006). This may include providing step-by-step guidance and modeling problem-solving strategies.

Science: Scaffolding is used to aid learners in comprehending scientific principles, conducting experiments, and exploring complex scientific concepts (Lin et al., 2012). Recently, scaffolding has been widely utilized to support learners' inquiry in science (Abels, 2015; van Uum, Verhoeff, & Peeters, 2017).

History and Social Studies: In history and social studies education, scaffolding helps learners understand historical events, analyze primary sources, and develop critical thinking skills (Saye & Brush, 2002).

Art and Music Education: In the arts, scaffolding is employed to assist students in developing their creative skills. This includes providing techniques and examples to guide artistic expression and music composition.

Scaffolding has proven effective across all levels of education, from preschool to primary, secondary, and higher education, offering numerous benefits in expanding learners' knowledge and improving their skills (Belland et al., 2017; Doo, Bonk, & Heo, 2020).

6.1.3 Scaffolding challenges and limitations

Scaffolding is indeed a valuable educational strategy, but it is not without its share of challenges and limitations (Maries, Lin, & Singh, 2017; Pressley et al., 1996). Some of the primary issues and limitations associated with scaffolding in education include:

Overreliance on Support: One of the most significant challenges is the risk of students becoming overly dependent on scaffolding. If scaffolding is not gradually reduced, students may struggle to work independently.

One-Size-Fits-All Approach: Scaffolding strategies that work well for some students may not be effective for others. Teachers need to tailor their scaffolding to individual student needs, which can be time-consuming.

Adaptive Scaffolding: Scaffolding often follows a linear progression, but learners have different rates of progress. Adaptive scaffolding, which adjusts in real-time based on individual student performance, is more complex to implement.

Assessment Challenges: Assessing when and how to reduce scaffolding can be challenging. Teachers need to monitor student progress and adjust support accordingly, which may be subjective.

Teacher Knowledge and Skill: Effective scaffolding requires teachers to have a deep understanding of both the subject matter and the scaffolding techniques. Inexperienced or unprepared teachers may struggle to provide effective support.

Time-Consuming: Implementing scaffolding can be time-consuming for teachers, particularly in one-on-one or small group settings. This can be a limitation in large classrooms with limited time.

Despite these challenges, scaffolding remains a valuable educational tool when applied thoughtfully and effectively. Additionally, with the advent of groundbreaking technologies, such as AI, many of these challenges and limitations can be overcome, as will be detailed in the next section.

6.1.4 Scaffolding and AI

In this section, we will discuss some ways in which scaffolding can be implied in AI-supported education, and how AI technology can be utilized to overcome or limit some of the challenges and limitations with scaffolding discussed above.

6.1.5 Overview

One way in which AI technology can help support scaffolding in education is that AI can provide a vast number of resources in no time, addressing the challenge of time constraints. Moreover, AI can analyze vast amounts of data swiftly and offer personalized support based on each learner's capabilities and needs. Therefore, by exploiting new technologies, scaffolding may continue to evolve and become even more responsive and effective, ultimately enhancing the learning experience for a diverse range of students.

6.1.6 Overcoming some challenges through AI technology

Another way in which AI can support (i.e., scaffold(!)) scaffolding is through dealing with the risk of overreliance on support. There are several possible causes for why a human teacher might provide too much support and fail to gradually reduce (fade) their support, including socio-emotional aspects (like wanting to be caring and supporting, not wanting the student to struggle) or lack of precise assessment of the needs of the students or a willing to show themselves useful, helpful and highly able. A carefully tuned or designed AI tool, though, such as a carefully designed prompt to guide interaction with an LLM, can overcome some of these weaknesses, thus not letting the student rely excessively on the support.

Another difficulty of scaffolding that the AI might be helpful in combatting is the need for individual and adaptive scaffolding. It might be difficult for a teacher who might have several students and teach several subjects to fine-tune his/her scaffolding efforts on each specific student. The ability of an AI to analyze huge amounts of data very quickly and offer

personalized support based on data regarding the performance, interactions and queries from each individual learner might provide a good ground for giving highly adaptive and individualized support, and hence effective scaffolding.

Knowledge. As noted above, effective scaffolding requires teachers to have a deep understanding of both the subject matter and the scaffolding techniques. Therefore, teachers may struggle to provide effective support, for several reasons. This is yet another way in which an AI technology can be used to make scaffolding more effective. This can be achieved in several different ways. The AI can be used by the students directly (such as in the case of the Study Buddy), so that they can acquire some of the information that the teacher would traditionally have needed to provide. On the other hand, an AI technology can also be used by the teacher, to provide information that the teacher can then relay, pass on or modify and provide to his/her students.

Skill. Also as noted above, except for knowledge or information about a subject matter, a teacher also needs specific skills in order to be able to effectively use scaffolding with his/her students. Again, an AI technology can help, in this case a teacher-faced technology (like the Teacher Mate), which can provide the teacher with support on how he/she can use scaffolding techniques with his/her students. That is, an AI can support the teacher in supporting his/her students, thus providing scaffolding for the scaffolding, if you will.

Assessment Challenges: As noted above, it might be difficult for a teacher to make the appropriate assessment of when and how to reduce scaffolding. One reason for this might just be the sheer volume of assessments that need to be made by a teacher who has many students, and the difficulties of constantly keeping up with the students' progress. It might therefore be a risk that the teacher e.g., keeps scaffolding for too long, not realizing that his/her student has grown enough not to need the specific support anymore (but instead perhaps a new scaffold on another level). This is a kind of task at which an AI might excel since it can tirelessly keep track of a student's progress and continuously update the evaluation of the students' progress and corresponding needs. Thus, the AI tool (such as the Teacher Mate) might prompt the Teacher that a student has reached a certain level, while a student-facing tool (like the Study Buddy) can change the way it responds to or presents material to the student.

Adaptive Scaffolding: Similar to what was said above regarding the assessment challenge, this is an area where an AI tool can be useful, since it can easily handle the different levels of progress (in different areas) by different students on different occasions, which might be very complex for a teacher to do without tools, or very time-consuming to do with conventional tools (like lists of student achievements).

7. Special needs and inclusive education and AI

7.1 Introducing special needs and inclusive education

Both defining special needs education and inclusive education come with some difficulties. If we first turn our attention to inclusive education, it has been noted that there is a “confusion and lack of consensus regarding the meaning of ‘inclusion’” (Edström et al., 2022, p. 3). Sometimes, inclusive education is characterized by the motto that “every learner matters and matters equally” (UNESCO 2017). But this is reasonably too vague, since someone can accept this norm, while still hold that the best way to approach education is not one in which all students are situated in the same classroom. (An obvious example that is seldomly discussed, is that many educational systems – but not all schools – separate students by age – something which could be considered a form of ageism, but one that is quite universally accepted).

According to Nilholm, “...inclusion means that all pupils should be participating socially and learn according to their prerequisites. Ideally, this would also involve the creation of communities in schools and classroom” (Nilholm 2021, p. 5)

Many researchers hold that the difficulties in using the expression ‘inclusion’ derives from the fact that it is an ambiguous term (e.g., Black-Hawkins 2012; Göransson and Nilholm 2014; Haug 2017; Lindqvist and Nilholm 2013; Magnússon 2019; Nilholm 2021). The Salamanca Statement itself has been criticized for being too vague and open to more than one possible interpretation of the meaning of the term inclusion (Magnússon 2019). The fact that researchers define inclusion in different ways complicates the use of this terminology (Nilholm 2006b).

Göransson and Nilholm (2014), in a survey of some of the most high impact research in North American and European journal articles on inclusive education, identified four different definitions of the term, ranging from placement (which they call inclusion level A), via inclusion as meeting social and academic needs of students with disabilities or of all students (inclusion levels B and C, respectively), to inclusion as the creation of communities where differences are being valued (inclusion level D). Interestingly, several different definitions where even sometimes used within a single research publication. (Göransson and Nilholm 2014)

7.2 Special educational needs

If the literature on inclusive education contains controversies, it is at least as present in the case of special needs education. Sometimes researchers talk about special needs education, at other times about special educational needs students (oftentimes referred to as SEN students).

It is not possible to generalize about SEN or SEN students easily and substantially, since there are many different situations and conditions that might be actualized. There are many different diagnoses and conditions proposed by researchers and classificatory manuals and different national and international institutions and organs. Many also consider special educational needs to be a broader category than necessarily having a diagnosis of some form. Thus, for example in Sweden, it is not necessary to have a diagnosis in order to qualify for some special educational support. But without going into too much detail here, we can provide a short overview of some main lines of the field, by briefly presenting some descriptions of some of the broad families of diagnoses and classifications that are sometimes made.

In the DSM-5, the American Psychiatric Association (2016) provide the following general description:

“The neurodevelopmental disorders are a group of conditions with onset in the developmental period. The disorders typically manifest early in development, often before the child enters grade school, and are characterized by developmental deficits that produce impairments of personal, social, academic, or occupational functioning. The range of developmental deficits varies from very specific limitations of learning or control of executive functions to global impairments of social skills or intelligence.” (American Psychiatric Association, 2016, p. 1)

Furthermore, they claim that “The neurodevelopmental disorders frequently co-occur; for example, individuals with autism spectrum disorder often have intellectual disability (intellectual developmental disorder), and many children with attention-deficit/hyperactivity disorder (ADHD) also have a specific learning disorder.” (American Psychiatric Association, 2016, p. 1) On the other hand, as we will return to below, there are also those students that have for example an ADHD or autism spectrum diagnosis who are also considered gifted students, and these students are often called twice exceptional (2e). (Holmgren et al., 2023)

Moreover, not all diagnoses present in the DSM-5 include only symptoms expressed as deficits. “For some disorders, the clinical presentation includes symptoms of excess as well as deficits and delays in achieving expected milestones. For example, autism spectrum disorder is diagnosed only when the characteristic deficits of social communication are accompanied by excessively repetitive behaviors, restricted interests, and insistence on sameness.” (American Psychiatric Association, 2016, p. 1) Turning our attention now to a diagnosis called intellectual disability (ID), it is in the manual:

“characterized by deficits in general mental abilities, such as reasoning, problem solving, planning, abstract thinking, judgment, academic learning, and learning from experience. The deficits result in impairments of adaptive functioning, such that the individual fails to meet standards of personal independence and social responsibility in one or more aspects of daily life, including communication, social participation, academic or occupational functioning, and personal independence at home or in community settings. [...] Intellectual disability may result from an acquired insult during the developmental period from, for example, a severe head injury, in which case a neurocognitive disorder also may be diagnosed.” (American Psychiatric Association, 2016, p. 1)

Apart from what has been described above, the DSM-5 manual also includes descriptions of what it calls communication disorders. In its general description of these, it states that the “communication disorders include language disorder, speech sound disorder, social (pragmatic) communication disorder, and childhood-onset fluency disorder (stuttering).” (American Psychiatric Association, 2016, p. 1)

There are of course many other disabilities than those described above, that are recognized or proposed by researchers and theorists. For example, there are several forms of visual impairments, such as blindness, or hearing impairments, such as deafness, that are also relevant to have in mind when thinking about special educational needs and inclusive education.

7.2.1 Giftedness

While not always considered an educational special need, it can be argued that what is sometimes called giftedness, or special educational talent, is in fact also a form of special

educational need. Gifted students are repeatedly reported to experience many different negative situations and emotions in relation to their schooling. Many gifted students suffer great harm as a result of not being understood and not being provided the needed educational support from school. Appropriate educational strategies towards these students oftentimes include being provided with special educational arrangements such as enrichment (which is sometimes defined as a “horizontal extension of the curriculum ...” (Wardman & Hattie, 2019, p. 323)), or acceleration (i.e. a “vertical extension of the curriculum” (Wardman & Hattie, 2019, p. 323), meaning being allowed to skip content or move faster through the curriculum, for example through grade skipping or dual enrolment). In short, it can be said that these students need more challenge and stimulation from school than they are getting through an orthodox education. As a consequence of a one-size-fits-all approach to education, these students therefore are oftentimes gravely under-stimulated in school, being given boring or repetitive tasks that they already long ago could deal with.

The gifted education research area is rapidly expanding in Sweden (Holmgren et al., 2023) and in many other countries in Europe and worldwide. Nonetheless, it is currently difficult to give a single description of giftedness that would be accepted even by all theorist in the field, since multiple and differing definition proposals in the literature. For example, Sims (2021), surveying over 90 research articles, found more than 70 traits and abilities that, alongside having a high IQ, factor into different definitions of giftedness. Similarly, Klingner (2022, p. 1) states that “[u]nfortunately, there is no consensus among educators and psychologists for a comprehensive definition of gifted [sic]”. Baldwin et al. (2015) also highlight the importance of defining twice exceptionality, stating that there has been no unified method for bringing together the best research into a single definition and that no single definition has been acknowledged by both researchers and practitioners.

Sometimes, the giftedness is also coupled with learning disabilities or neurodevelopment disorders such as ADHD or autism-spectrum disorder. In these cases, it is common to denote these students as twice exceptional (2e). (Cf. Holmgren et al., 2023)

Due to the complex situation of the twice exceptional students, and the quite widespread lack of understanding among teachers about 2e students, they oftentimes face many negative experiences in school. (Holmgren et al., 2023) For example, Lee and Ritchotte (2018) claim that the relative lack of understanding of twice exceptionality is a barrier to nurturing the students’ talents, and it might also lead to underachievement in school and frustration (Dare & Nowicki, 2015), lead to negative impacts on their socio-emotional well-being (Foley-Nicpon et al., 2012), and therefore lead to long-term negative outcomes for these individuals, both as children and in their adult lives. Several studies have found that 2e students experience several psychological vulnerabilities, and often exhibit low-academic self-concept, low academic self-efficacy, and low self-esteem (Foley-Nicpon et al., 2012). These vulnerabilities may cause the unreasonably high risk of academic failures of 2e students found in many studies (e.g., Wang & Neihart, 2015). It is oftentimes argued that to help these students, it is important that school also focus on 2e students’ strengths and their areas of interest, not only their potential weaknesses. (Holmgren et al., 2015) When a student is allowed to succeed, it will likely lead to an increase in academic self-concept, and thereby also benefit their learning.

7.3 Challenges to inclusive education

Theorists, philosophers of education and special needs education researchers are currently in something of a debate concerning whether, and to what extent, inclusive education is a reasonable ideal, but also a practically feasible approach to education. There are also differences between European countries regarding inclusive education. For example, Italy has an inclusive educational system, while Sweden has a system in which e.g., students

diagnosed with intellectual disabilities are (oftentimes) placed in special classes or following a special curriculum, outside of mainstream education. (cf. Edström et al., 2022)

Proponents of an inclusive education has several possible arguments to their favor, such as that it seems a better fit with democratic and egalitarian ideals, that there could be strengths and educational benefits in diversity (cf. the community level of inclusive education), and so on.

On the other hand, those who question inclusive education tend to do that based on practical arguments, such as that it is not feasible to for all students (of a given age) to be part of the same class in mainstream school, but that some SEN students ought to instead be educated outside of mainstream education. Some are claiming that this would be in the interest of and for the benefit of the SEN students themselves, for the other students in the mainstream class, or for both.

That is, proponents of inclusive education tend to claim that inclusive education is the ideal educational design, something which the critics of inclusive education might not need to reject. Hence, if we could rid ourselves of the alleged hindrances for inclusive education, it seems that all would be able to join ranks under the banner of inclusive education. We will below briefly investigate whether AI technology can provide support in such an endeavor.

7.4 Special needs and dialogic education

While there is a general lack of research in the field, some pioneering studies have been carried out in the area of dialogic education for persons with different forms of special educational needs. For example, it has been shown that philosophical dialogs have quite strong positive effects on communicative and cognitive skills and abilities in the form of group argumentation development for persons with acquired brain injuries (Backman et al., 2020), including persons with aphasia. In the latter case in particular, special technological tools based on digital computer game technology has been developed, aimed at supporting persons with acquired brain injuries – specifically those with aphasia – in participating in the dialogs (Backman et al., 2021; 2022b). Such tools could potentially also be used in other target groups. We will return to this below. Moreover, it has been shown that participation in philosophical dialogs is both possible for, and can have several positive effects for, persons with autism spectrum diagnoses (Gardelli et al., 2023). A study has also provided evidence that such participation is beneficial to a wider group of students with differing neurodevelopment disorders or diagnoses (Backman et al., 2022a)

7.5 AI technology, special needs and inclusive education

Let us now once again turn to issues of how AI technology relates to this educational aspect at hand. First, we shall investigate some potential benefits of AI technology in a special needs educational context, including some thoughts on AI and inclusive education. After that, we will turn to some risks related to AI technology and special needs and inclusive education.

7.5.1 Potential benefits of AI in special needs and inclusive education

AI-based tools promise to provide support for students in several different needs of special support. For example, a student with reading-difficulties might use AI-based tools to for example read a text out loud for him, or provide a summary of a given text, or to find a specific piece of information in a larger text. This might mean that students with reading-difficulties might be able to participate in learning activities together with peers in ways that would otherwise have been much more difficult or perhaps proactively not possible.

Other examples include tools geared towards students with hearing-impairments (such as voice-to-text tools), with visual impairment (such as text-to speech technology or other machine-vision based tools), or persons with aphasia or acquired brain injuries (cf. Backman et al., 2021; 2022b).

All of these, and many other possible, applications of AI technology are very interesting from the perspective of special needs education and inclusive education. They might quite drastically shift what we today see as special needs students, and their chances to participate in the classrooms compared to what is currently the case. In summary, it can be said that well-designed and implemented AI technology, and accompanying pedagogical strategies, might hold promise to further democratize education and lead to more equal and equitable education across Europe and the globe.

As such, AI technology might be an important step in the direction of making inclusive education a real possibility, by helping to overcome some of the challenges that some people consider inclusive education to currently face.

Due to this, special needs and inclusive education can be seen as a major part of the educational foundations and the educational affordances of AI technology. It is interesting to further investigate whether well-designed AI tools can bring about the paradigm shift that many educational theorists have been advocating for many decades, but that has still yet to materialize fully in schools around the globe, and which is still facing opposition from many different directions.

7.5.2 Potential risks with AI in special needs and inclusive education

Let us now turn to some potential risks with using AI technology in AI and special needs and inclusive education. The risks we discuss here are of a practical and classroom-oriented nature.

Over-reliance of tools. While there might be possible strengths and affordances of above-mentioned technologies, there is also the corresponding risk that teachers and students develop an over reliance of such tools.

Long-term negative impacts on skills development. Related to the risk of over-reliance of tools, there is the long-term risk that students do not develop skills that they might otherwise develop, if they rely on AI-based tools to accomplish for them what they otherwise would need to practice doing themselves, which might have then promoted the training and development of those skills that the students might need. While this is a general risk facing all students, it can be argued that the risk is particularly pertinent with relation to students with special educational needs. For example, students diagnosed with dyslexia might be suggested to use AI-based tools to provide a summary of a text, thereby minimizing the need to read the text themselves. While this in the short run might mean that they gain higher chances of participating in an educational activity through an increase in accessibility to the information that other students might have, it might in the longer run mean that they get less training in reading, which might further increase the problems with reading that they were already facing.

8. Interpretation of workshop data

In this section, we shall turn our attention to some of the data from the workshops. More precisely, we will use the pedagogical approaches discussed above, as well as two sets of theories on how on the one hand students, and on the other teachers, can use AI technology. All of these has been used to deductively code parts of the qualitative data gathered from the workshops, parts where teachers and students in the workshops – held in several different countries over a period of several months – give their views on possible future uses of AI technology in education. It should also be noted that other things surfaced in the workshops as well, such as fears and worries with the technologies, concerns about unethical uses – for example worries of overreliance of tools, of negative impact on students critical thinking or reasoning skills, of general negative impacts on education or problems on the future labor market, and the like. These will not be the focus on the present text but presented elsewhere.

In our workshops, students and teachers were given the possibility to reflect upon AI technology and its possible uses in their (future) education, school, and classrooms. Of course, some of the strategies were mentioned more frequently than others, but we have not made any structured quantitative analysis of the data, and hence will report it solely as qualitative data (as well as some quasi-quantification, like sometimes noting that a kind of answer was “rare”, and another was “frequent”). This makes sense given the way that the workshops were conducted, and the data was collected. A possible suggestion for a research study is to use these approaches for a deductive coding and collect data in a way that makes reasonable a quantitative processing of the data. Beyond investigating frequencies of mentions of the different strategies, it would be interesting to investigate whether there is any covariance between suggested strategy and e.g., what broader pedagogical approach that each respective participant suggests (such as dialogical pedagogy, scaffolding, etc.).

8.1 Seven strategies for student interaction with AI

In the paper “Assigning AI: Seven approaches for students with prompts”, Mollick and Mollick (2023a), suggest different ways that students can use AI technology, namely LLMs such as ChatGPT, in educational settings, “each with distinct pedagogical benefits and risks” (Mollick & Mollick, 2023a, p. 1). We will call these *possible strategies* and have used these seven possible strategies as a theoretical framework for deductive coding of our workshop data. In this chapter, we will first briefly present and describe these, and thereafter present the results from this coding.

The different possible strategies that Mollick and Mollick (2023a) suggest are the following:

1. AI as tutor,
2. AI as coach,
3. AI as mentor,
4. AI as teammate,
5. AI as simulator,
6. AI as student, and
7. AI as tool

8.1.1 The seven strategies described

Let us now go into a little more detail regarding what each and every one of these strategies consists of.

AI as tutor. The strategy of using the AI as tutor consists of helping students learn through having the AI act as a tutor, “providing direct instruction and educational guidance” (Mollick

& Mollick, 2023a, p. 11) to students. This is done because tutoring, “particularly high-dosage tutoring, has been shown to improve learning outcomes [..., and typically] involves small group or one-on-one sessions [...] focusing on skills building” (Mollick & Mollick, 2023a, p. 11). Students benefit from this process “by paying close attention to a skill or topic, actively working through problems, and getting immediate feedback as they make progress” (Mollick & Mollick, 2023a, p. 11). Mollick and Mollick (2023a) claim that tutoring is “inherently interactive and can involve a number of learning strategies” (Mollick & Mollick, 2023, p. 11), including:

questioning (by both the tutor and the student); personalized explanations, and feedback (the tutor can correct misunderstandings in real-time and provide targeted advice based on the student's unique needs); collaborative problem-solving (tutors may work through problems together with students, and not just show them the solution); and real-time adjustment (based on the student's responses and progress, a tutor may adjust the pace, difficulty level, making the learning process dynamic and responsive) (Mollick & Mollick, 2023a, p. 11)

Crucially, the tutor’s value is “not merely subject knowledge, but also their capacity to prompt the student to make an effort, pay close attention to the material, make sense of new concepts, and connect what they know with new knowledge.” (Mollick & Mollick, 2023a, p. 11)

AI as coach. The strategy of using the AI as coach consists of prompts from the AI to “help and direct students to engage in a metacognitive process and help them articulate their thoughts about a past event or plan for the future by careful examination of the past and present” (Mollick & Mollick, 2023a, p. 18). This is done to help students engage in metacognition, which is important for several reasons, among others that learning “requires motivation and self-regulation [and that learners] must be motivated to put in the work to make sense of new ideas. They also need to continually monitor and regulate their own thinking and learning” (Mollick & Mollick, 2023a, p. 18). All of these are metacognitive processes, and educators “have long recognized the importance of metacognitive self-monitoring to help students deepen their understanding and change their behavior” (Mollick & Mollick, 2023a, p. 18).

AI as mentor. The strategy of using the AI as mentor consists of using the AI to “help students get frequent feedback as they work by providing immediate and adaptive reactions to their projects” (Mollick & Mollick, 2023a, p. 6). This is done because making “mistakes can help students learn, particularly if those mistakes are followed by feedback tailored to the individual student [..., which is] timely and goal-oriented, helping students achieve their objectives” (Mollick & Mollick, 2023a, p. 6).

AI as teammate. The strategy of using the AI as teammate consists of using AI tools to “help teams [of students] increase their collaborative intelligence” (Mollick & Mollick, 2023a, p. 26). Helping students increase their collaborative intelligence is important in school for several reasons, among them that “[t]eams can outperform individuals working alone on many tasks, [... since teammates] can provide social support and, crucially, different perspectives, challenging each other to question points of view and initial assumptions.” This connects very well to dialogic education, as we have seen above. And this is valuable since a “diversity of perspectives can lead to a broader understanding of a problem and better-informed decisions” (Mollick & Mollick, 2023a, p. 26). Hence, an AI can be used to “prompt individuals to recognize and balance skill sets on any team, and it can play ‘devil’s advocate’ helping teams question their underlying assumptions and providing alternative viewpoints for any decision” (Mollick & Mollick, 2023a, p. 26).

AI as simulator. The strategy of using the AI as simulator consists of using the AI to practice skills and situations that it might otherwise be difficult to practice. Mollick and Mollick

(2023a, p. 38) suggest that one way to “challenge students to think in new ways is to prompt the AI to build a role-playing scenario, [...], pushing students to problem solve and make a consequential decision and giving students feedback about their performance.” This can be beneficial since practice can help students synthesize what they know and that actively applying a concept “in a novel situation requires a level of automation – students must ‘think on their feet’ as they apply what they know in a new way [which] activates hard thinking as students are pushed out of their comfort zone” (Mollick & Mollick, 2023a, p. 38)

AI as student. The strategy of using the AI as student is important due to the learning that often takes place when we try to help others learn – the power of teaching. Unfortunately, even though the authors recognize this at the onset of explaining this strategy, in the description they give, they do not fully manage to do justice to this idea. That is, when they describe this strategy, they state that the AI can be used by “students with knowledge of a topic, [...] as a way to check their understanding and fluency about that topic, [through letting] students ‘teach’ the AI about the topic by evaluating its output and explaining what the AI got right and wrong or what it may have missed.” (Mollick & Mollick, 2023a, p. 33) While “check[ing] their understanding and fluency” is also an interesting feature of using the AI as a student, they do not mention the potential learning involved. Hence, we suggest the following update to the description of using AI as a student:

the AI can be used by students with knowledge of a topic by trying to ‘teach’ the AI about the topic, evaluating its output and explaining what the AI got right and wrong or what it may have missed, as a way to check their own understanding and fluency about that topic, but also to increase their own understanding and furthering their own learning about the topic. (our suggested modification)

The reasons for doing this are many. For example, citing Carey and also Willingham, Mollick and Mollick note that:

“Teaching others helps students learn (Carey, 2015). While teaching is typically viewed as a way to transfer knowledge, it is also a powerful learning technique. When a student teaches someone else, they have to organize their knowledge and uncover the extent to which they understand a topic. Explaining concepts to others prompts students to piece together the elements of a concept, explicitly name those elements, and organize their knowledge so that it can be readily articulated (Willingham, 2023)” (Mollick & Mollick, 2023a, p. 33).

AI as tool. The strategy of using the AI as tool is differently presented than the others, its presentation consisting only of the authors briefly stating that as “a general-purpose technology, AI tools can be used in a wide variety of ways [... including] AI as a tool for extending the amount of work that students can do and accomplish.”

8.1.2 The workshop data and the seven strategies

Let us now turn to investigating how each of these strategies, if at all, were present in the responses given by the participants of the workshops. Regarding the way that our participants were envisioning that students might come to use the AI tools corresponded to all of the seven strategies suggested by Mollick and Mollick (2023a), although some were more frequent than others. Below, we will present examples of how each of these were mentioned in the data.

AI as tutor. The strategy of using the AI as tutor was raised in the workshop, as evident for example by the following excerpt, when a participant suggested that it would be good if the AI tool “[p]rovides students direct instruction and educational guidance”, or that the students could use the tool by asking “for explanations and examples” from the AI.

AI as coach. The strategy of using the AI as coach was raised in the workshop, as evident for example by the following excerpt, where a participant said that it would be good if the AI could be “[s]upporting students in their personal study and challenges, no matter how complex a situation may be”, or when a participant suggested that the AI could be “[h]eightening student engagement, confidence and motivation, giving more ownership” over the topic.

AI as mentor. The strategy of using the AI as mentor was raised in the workshop, as evident for example by the following excerpt: the AI tool can be used to “Provide feedback on students’ work (essay, project, presentation)” and also continuing that “We can add an additional constraint that if the student asks the AI to make the changes instead of herself/himself, the AI will encourage her/him to make a try first.” We can see that this lies close to the description of AI as mentor which was given above (using the AI to help students get frequent feedback as they work by providing immediate and adaptive reactions to their projects)

AI as teammate. The strategy of using the AI as teammate was raised in the workshop, albeit not perhaps as clearly as some of the above. For example, it can be seen in the following excerpt, where a participant claim that it would be good if the AI could help the student “Generate ideas and assist in essay writing”, or when a participant wishes for the AI to be able to help to “Diversifying learning strategies and scenarios”

AI as simulator. The strategy of using the AI as simulator was raised in the workshop, as evident for example by the following excerpts. For example, participants stated that they wished that the AI would help by “[c]reating questions, tests, activities, and homework for a wide scope of abilities equally for all students”.

AI as student. Although it was rarer than for example mentions of the AI as tutor or AI as mentor strategies, the strategy of using the AI as student was actually raised in the workshop, as evident for example by the following excerpt, where a participant stated that it would be good if the AI could “request explanations” from the student.

AI as tool. The strategy of using the AI as tool was raised in the workshop, in several different occasions where participants requested different specific use cases from the AI tools, such as the ability to “[i]dentify and highlight essential information from long passages and texts [that the students] study”, enable translation between different languages or in that it would support gamification of the education.

To conclude, the above suggests that the future users of the AI4EDU tools – teachers and students – have a rich and complex understanding of different ways in which AI technology can be used in school, but they also have high demands of what they expect the tools to be able to contribute, and what support they wish to receive from the tools.

8.2 Five strategies for teacher interaction with AI

In a paper geared towards teachers, “Using AI to Implement Effective Teaching Strategies in Classrooms: Five Strategies, Including Prompts”, Mollick and Mollick (2023b) suggest ways that teachers might implement AI technology in their classrooms. These five strategies are:

1. providing multiple examples,
2. providing multiple explanations,
3. frequent low-stakes testing,
4. assessing student learning, and
5. distributed practice

8.2.1 The five teacher strategies described

Let us now go into a little more detail regarding what each one of these strategies consists of:

Providing multiple examples and explanations. This first use case is quite straightforward. The authors note that “Students need many examples when learning complicated concepts [... and that when] confronted with new and complex ideas, adding many and varied examples helps students better understand them.” (Mollick & Mollick, 2023b, p. 3)

Providing multiple explanations. This second use case is related, and also quite straightforward. The authors note that “Teaching involves logical and coherent explanations [and that] [e]ffective explanations lay the groundwork for foundational knowledge that helps students build mental maps of topics.” (Mollick & Mollick, 2023b, p. 7) Furthermore, they add that producing many explanations “is a complicated and time-consuming task for a variety of reasons: student knowledge varies across any subject; some concepts are abstract, or wholly unfamiliar to students who may need multiple explanations adapted to their level of understanding” (Mollick & Mollick, 2023b, p. 8). They claim that “The AI can help instructors with this task by generating multiple explanations from a variety of perspectives, by generating explanations that use a step-by-step approach and adding details to any existing explanations.” (Mollick & Mollick, 2023b, p. 8).

Frequent low-stakes testing. The third strategy consists of using AI to frequently develop short and quiz-like tests for the students. The authors claim that “Low-stakes frequent tests are an effective teaching strategy across educational levels and settings. Tests do not simply measure knowledge; they are a learning event. Repeated testing and retrieval of knowledge help students retain information in the long term” (Mollick & Mollick, 2023b, p. 12). These tests are supposed to both help stimulate students’ memory and to “provide students with feedback about their understanding of the material, allowing them to focus their efforts on the gaps in their knowledge and adjust their learning strategies” (Mollick & Mollick, 2023b, p. 13).

Assessing student learning. The fourth strategy consists of using AI to help assess students’ current knowledge and understanding. The authors state that assessment “can help instructors and students monitor their learning and understanding of the course material. These are important because they can provide immediate feedback to both instructors and students about what students know and, crucially, what students are confused by” (Mollick & Mollick, 2023b, p. 16).

Distributed practice. The fifth and final strategy is concerned with making sure that students engage with the learning material repeatedly and distributed over time. They claim that students “need to practice retrieving new information not just once but multiple times during a course. Distributed practice, or having students practice material several times over days and months, is critical to developing robust and flexible knowledge”, and that “[d]istributing practice across time and activities can help students make connections and help make information more easily retrievable” (Mollick & Mollick, 2023b, p. 19).

8.2.2 The workshop data and the five teacher strategies

Let us now go into a little more detail regarding what each one of these strategies consists of:

Providing multiple examples and explanations. Because these first two strategies are quite similar, and related, and are concerned with concepts that participants tend to connect, we will present these two together. For example, participants stated that they wished that the AI tools could help to “explore concepts: define key terms, search for definitions, simplify definitions, search for examples”. Participants also mentioned a wish that the AI tools could

“create teaching materials [and] create teaching notes (lists of key concepts to learn, definitions, examples)”. Participants also wanted to be able to query the AI tool for “explanations and examples”.

Frequent low-stakes testing. Participants stated that they wanted AI tools to be able to “create worksheets (comprehension questions, quizzes, critical thinking questions)”, and “generate comprehension questions”.

Assessing student learning. Relating to the above, participants also wanted the AI tools to be able to “assign activities to students (quizzes and open-ended questions) and receive their answers” as well as “automatic grading of their answers”. Participants also asked for the ability of the tools of “evaluating students’ activities and homework quickly and with effective, personalized feedback”.

Distributed practice. There were also mentions of the wish for the tools to be able to help provide opportunities for distributed practice, such as recurring tests or homework for the students.

8.3 The pedagogical approaches and the workshop data

Let us now, finally, turn our attention to the different approaches to education discussed in the first chapters of this text, and investigate if, and how, these were taken up by participants in the workshops.

Student-centered education. A lot of the things expressed by the participants can be said to be relating to the AI tools helping to support a student-centered approach to education. This can be seen for example in statements like that the AI tools should be able to “Support[] students in their personal study and challenges, no matter how complex a situation may be”, or that several participants, as noted by one of the staff conducting the workshops, “recognized [the AI tool’s] ability to stimulate interest and activate students’ attention, reflecting a positive outlook on its impact”, or that the tools should be “[h]eightening student engagement, confidence and motivation, giving more ownership”.

Inquiry-based education. There were also some references that could be taken to relate to an inquiry-based approach to education. For example, the following not from one of the workshop leaders: “Teachers emphasized Study Buddy’s potential to enhance students’ research skills and promote engagement”, or when participants suggested that AI tools could be used for “Debates (students vs. AI)”, which can be seen as a kind of inquiry-based educational approach, albeit perhaps not a dialogic one (since dialogs are often contrasted with the debate, the latter being a situation not aimed at joint inquiry into a subject, but rather the persuasive attempt to win someone over).

Dialogic education. There were also some mentions of the AI tools potential use in dialogic educational settings. Among these are examples like the following, where participants stated that the AI tools could be used to “[g]enerate ideas and assist in essay writing”, “request explanations” from the student, which would be at least a step into them entering at least what we above called a covert quasi-dialog. A very clear and obvious reference to dialogic education is when participants stated that they wanted the AI to be able to “[c]reate group discussion topics and moderate discussion”.

Scaffolding in education. Also, educational scaffolding can be seen in the data from the workshops. Examples include: “provision of concise and synopsis educational content in the curriculum areas and in subject specific areas”, “[s]how where i could improve and give me inspiration”, or “[p]rovides students direct instruction and educational guidance.”

Special needs and inclusive education. There were also mentions of Special needs and inclusive education in the workshop data. For examples, participants requested that the AI tools should be able to create “questions, tests, activities, and homework for a wide scope

of abilities equally for all students”, or to be able to suggest “educational concepts, scenarios and challenges for students of all abilities”.

Thus, all our pedagogical approaches were also represented in the workshop data. Yet again, this shows that the future users of the AI4EDU tools – teachers and students – have a rich and complex understanding of different ways in which AI technology can be used in school, but they also have high demands of what they expect the tools to be able to contribute, and what support they wish to receive from the tools.

9. Conclusions

We have presented several key pedagogical concepts and approaches, and critically investigated and evaluated how AI technology can influence these. It has been found that there are reasons to believe that well-designed AI technology holds promise to be able to positively influence or support these in several ways. On many occasions, it has been suggested that well-designed AI tools can support these pedagogical approaches through mitigating or eliminating some of the typical weaknesses or challenges with the respective approaches. For example, AI tools can help make scaffolding more adaptive and individualized through helping teachers effectively assess and continuously reassess each student’s progress, or help overcome the challenge of fact-checking on the fly in inquiry-based dialogic education by providing students or teachers with a quick and easy way of acquiring factual information on a vast amount of topics, and presented in a clear and accessible way, in very short time. It has also been argued that well-designed AI technology might support special needs education and unlock important routes to an inclusive education for all.

On the other hand, we have also raised some risks that AI technology in education could sometimes have adverse effects, such as overreliance on tools leading to decreased learning or delayed or eliminated development in certain areas.

It should be kept in mind that this deliverable has been speculative, and that the kinds of tools discussed might not yet exist and might also be difficult to construct. It should also be kept in mind that even if a tool exists, it might not be that the users – teachers and students – are not able to fully unlock and make use of its potential, for several reasons, both having to do with the design and implementation of the tool and with the skills and competencies of the users. It should also be kept in mind that this deliverable has largely been concerned with discussing potential benefits of such technology, along with a few sketches of potential practical risks or adverse effects that may arise but has not been engaged with many large and pressing issues and controversies that this technology raises.

Thus, there is a need for more research, of several different kinds, ranging from philosophical through pedagogical to technical, as well as for well-designed AI tools and accompanying well-designed educational approaches to use and respond to the technology.

The outcomes of this report will direct the technical specifications (as reported in D2.2) for the development of AI4EDU applications, as part of the WP3 tasks. Additionally, it will guide the definition of the evaluation methods and criteria for the developed AI4EDU applications in real educational settings in the four project countries, which is the main objective of WP4 and WP5, in terms of usability and technology acceptance, as well as of the educational impact on teaching and learning, respectively.

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Appendix 1: School Workshop Preparation

The main purpose of the workshop is collecting initial user requirements and needs on conversational AI assistant for teaching and learning from both the educational agents involved (teacher and students).

Workshop Structure

Step1: Level of technology awareness

Objective: Assess how familiar both students and teachers are with the AI tools that can be utilized for educational purposes.

Method: The approach involves distributing two questionnaires to a selected group of teachers and students to obtain a general idea of their current knowledge of the available AI technologies. The questionnaire may be shared prior to or on the same day as the workshop, and participants will be given 15 minutes to complete it.

Tools: The questionnaire will be available in two formats.

- Hardcopy format
- Online format
 - Teacher online form <https://forms.office.com/e/ckPiMBTFBC>
 - Student form Pre <https://forms.office.com/e/NdfgSXck6Y>

Time: 15 minutes

Step2: Welcome and technology Introductory workshop

Objective: Provide a brief presentation of ChatGPT (Generative Pre-trained Transformer) and its applications and help them understand the basics of how GPT works.

Method: Parallel workshops for both students and teachers (or two workshops on two different days) will be conducted to enrich the understanding of ChatGPT technology, as described in the following sections.

Student Workshop

Begin by introducing students to AI in general then to ChatGPT, as one of the common application these days in AI. Explain how GPT is a machine learning model that can generate human-like text by predicting the words that are most likely to follow a given sequence of words. Show them examples of GPT-generated text to give them a sense of what it is capable of. (20 minutes)

Activity 1: Explore GPT-generated texts.

In this activity, students will be given a set of GPT-generated texts and asked to analyze them for their coherence, logicity, and correctness. This activity will help students understand the potential benefits and risks of GPT. (30 minutes)

Instructions:

Divide students into small groups of 3-4.

Give each group a set of GPT-generated texts (5-10 texts).

Ask each group to read the texts and analyze them for coherence, logicity, and correctness.

Ask them to fill in the given online Student Observation form (<https://forms.office.com/e/9ZhLYVMjGi>) to share their written observations and discuss the potential benefits and risks of GPT-generated texts as a tool for written communication.

Ask each group to present their findings to the class.

Activity 2: Interact with Study Buddy.

In this activity, students will use the Study Buddy, powered by ChatGPT-3.5 API, to generate text on their own. They will be given a text prompt and asked to write a short story, poem, or blog. This activity will help them understand the process of GPT and how it is used to generate human-like text. (45 minutes)

Instructions:

Explain students that they will be using the Study Buddy to generate text.

Show them how to access the Study Buddy and provide them with the necessary credentials and documentation.

Give them a text prompt for their writing, such as "Write a short story about a time when you felt proud of yourself."

Ask them to use the Study Buddy to generate text based on the prompt and write a short story or a blog post.

After they have generated the text, ask them to read it aloud to the class and discuss the quality of the text generated.

Assign one person from the group to write a very short text on a given prompt herself/himself, use ChatGPT to generate a text and compare the two texts.

Time: 90 minutes for each workshop

Teacher Workshop

Begin by introducing teachers to AI in general, then to GPT as one of the common applications in AI these days. Explain how GPT is a machine learning model that can generate human-like lesson plans. Show them examples of GPT-generated lesson plans to give them a sense of what it is capable of. (15 minutes)

Activity 1: Explore a GPT-generated lesson plan.

In this activity, teachers will be given a lesson plan generated by ChatGPT and asked to analyze it for its coherence, logicality, and correctness. This activity will help teachers understand the potential benefits and risks of GPT. (30 minutes)

Instructions:

Divide teachers into small groups of 3-4.

Give each group the lesson plan.

Ask each group to read the lesson plan and analyze it for coherence, logicality, and correctness.

Ask them to fill in the online form (<https://forms.office.com/e/VXKnv2MYeL>) to share their written observations and discuss the potential benefits and risks of GPT-generated lesson plan.

Ask each group to present their findings to the others.

Activity 2: Interact with Teacher Mate

In this activity, teachers will use the Teacher Mate tool, powered by ChatGPT-3.5 API, to generate a lesson plan on their own. They will be given a text prompt and asked to write a lesson plan for their subjects using the tool. This activity will help them understand the process of GPT and how to use it to generate human-like text. (45 minutes)

Instructions:

Explain to teachers that they will be using the Teacher Mate tool, powered by ChatGPT-3.5, to generate a lesson plan.

Show them how to access the Teacher Mate and provide them with the necessary credentials and documentation.

Give them a text prompt for their action, such as "pick up a topic related to your subject and try think of the best lesson plan to conduct this session."

Ask them to use the Teacher Mate to generate the lesson plan.

After they have generated the plan, ask them to read it aloud to the class and discuss the quality of the plan generated.

Step3: Open-use workshop

Objective: The aim is to gather a diverse set of potential use cases and scenarios for Study Buddy and Teacher Mate that can be utilized by both teachers and students.

Method: The approach involves conducting two separate workshops, one for teachers and one for students, or two workshops held on different days. During the workshops, users will be given the freedom to use Study Buddy and Teacher Mate without any guidance or instructions. The same activity will be conducted in both workshops, which involves exploring various potential applications of conversational AI tools. The activity will last for approximately 60 minutes.

Students and Teachers Workshop

Common Activity: Explore the different possible usages of Study Buddy / Teacher Mate (60 minutes)

Instructions:

Divide participants into small groups of 3-4.

Ask each group to think of different possible use cases as follows:

In a typical school week, what were the main tasks you had to carry out? (e.g., create prompts for tests, grade tests, create worksheets and lesson plans, find topics for essays, prepare for a new lesson that you have not taught before, create a presentation for a lesson, create supporting material for a lesson, etc.). Consider how AI can help you with these tasks and ask questions accordingly.

Ask them to fill in the online form (<https://forms.office.com/e/R131HQiB6p>) to share their written observations and discuss the potential benefits and risks of using GPT for these use cases.

Ask each group to present their findings to the others.

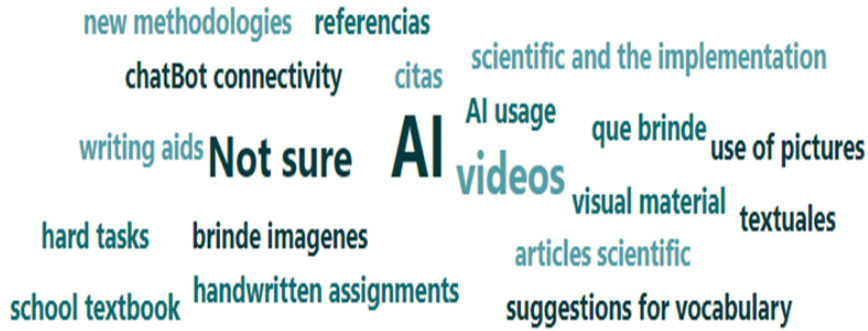
Additional Resources:

- GPT-3 Playground: <https://beta.openai.com/playground/>
- A Beginner's Guide to GPT-3: <https://towardsdatascience.com/a-beginners-guide-to-gpt-3-422b0ebaa505>
- The Future of GPT-3: <https://www.analyticsinsight.net/the-future-of-gpt-3-and-its-limitations/>

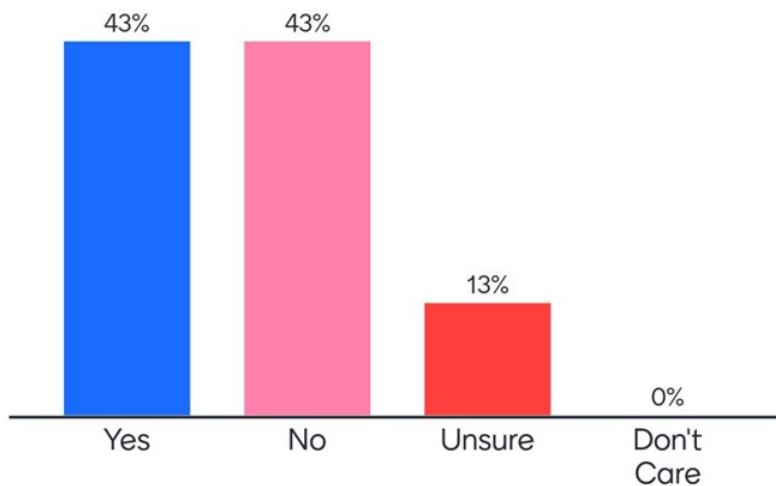
Appendix 2: Quantitative analysis of workshops data

Survey Analysis

What features would you like to see in future updates of these technologies?
(Teachers)



Are you familiar with the use of AI in education (teaching / learning) today?
(Teachers)



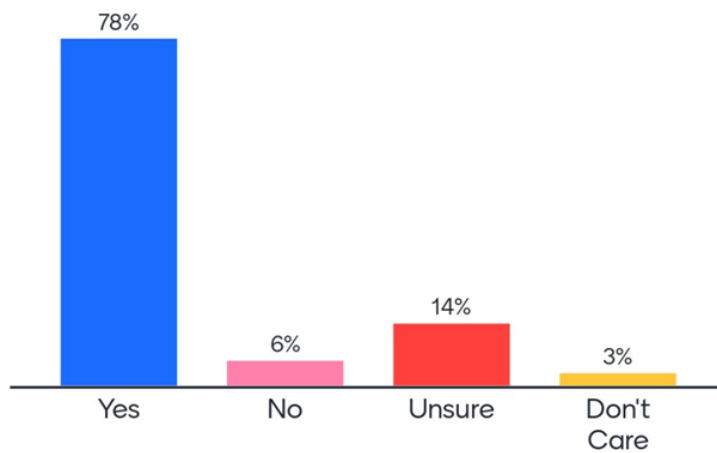
To which extent do you think that AI should be used in the future learning and education? (Teachers)



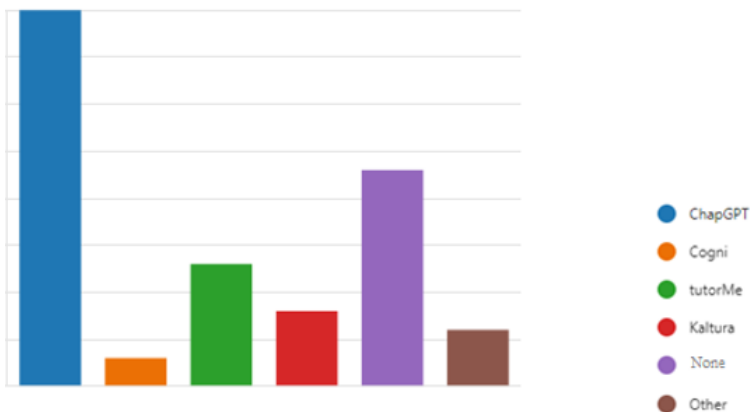
What words, in your opinion, positively describe the use of AI in 21 century education? (Teachers)



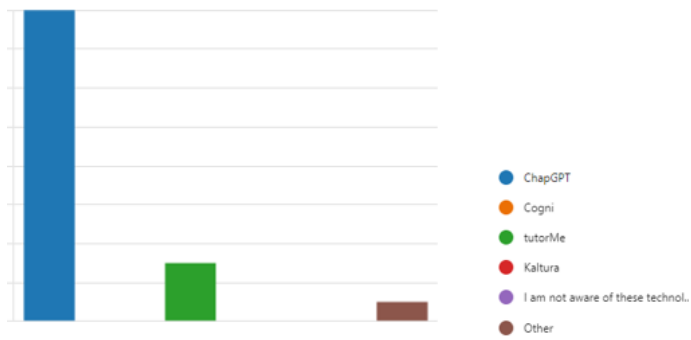
Do you believe that AI has the potential to play a significantly positive role in education today? (Teachers)



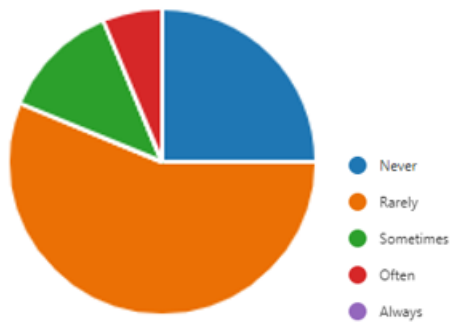
Are you familiar with artificial intelligence technologies such as ChatGPT, Cogni, Kaltura, tutorMe? Choose the ones you've heard of. (Teachers)



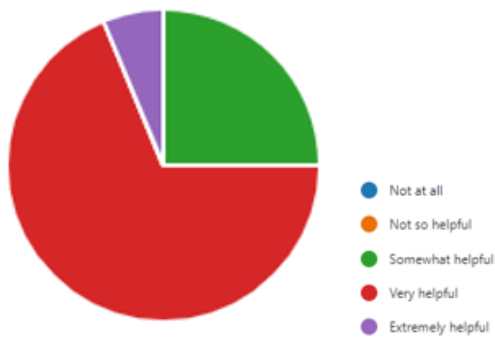
Are you familiar with artificial intelligence technologies such as ChatGPT, Cogni, Kaltura, tutorMe? Choose the ones you've heard of. (Students)



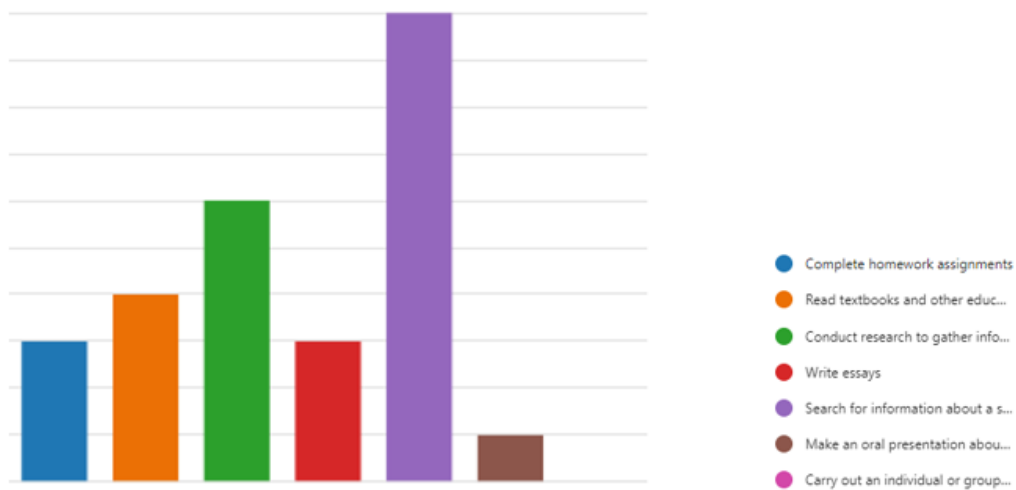
How often do you use AI in your current study and learning? (Students)



To what extent do you think such kind of AI tool might be helpful in the learning process? (Students)



Have you ever used AI while doing the following tasks? (Students)



What are the features that you would like to have while using AI in education? (Students)

"I wish he could explain something I don't understand at school."

"to remember", "To find information about a topic"

"I would like him to help me with questions I may have in homework"

"For help with some difficult exercise"

"In handling easy daily tasks so that we can deal with more important events"

"to help me with math problems"

To what extent should AI be used in future learning and education? (Students)



Appendix 3: Qualitative Analysis of workshops data

Observation while students using ChatGPT as a tool.

Observations following the use of ChatGPT reveal both strengths and limitations. The evaluation of the outcomes produced by ChatGPT points to certain drawbacks, such as an oversimplified approach and a tendency to generate responses that are too general. The text generated by the machine is notably error-free, making it easily distinguishable as machine-generated due to its lack of mistakes. Furthermore, when crafting questions for students of different age groups, the impact is perceived as minimal, as the responses do not seem tailored to specific age-related nuances. Additionally, the generated text tends to deviate from prescribed length restrictions.

Despite these limitations, there are distinct advantages to using ChatGPT. It exhibits remarkable efficiency and speed in generating responses. One of its notable strengths is its adaptability to various age groups and proficiency levels, providing advanced answers while also adjusting the tone and content to suit different age demographics. An interesting aspect is its ability to produce professional responses when prompted as an “expert” and to incorporate emojis when generating content from the perspective of a six-year-old.

However, it is essential to acknowledge certain concerns associated with the use of ChatGPT. These include the potential for generating content that induces fear, a lack of scientifically proven credibility in its responses, the possibility of plagiarism, the dissemination of incorrect information, and a reliance on data provided during training, potentially rendering the generated content not up to date. Despite its notable advantages, careful consideration of these limitations and concerns is imperative when utilizing ChatGPT in various contexts.

Observation while students use AI4EDU prototype (Study Buddy) as a tool.

Several noteworthy observations have emerged, particularly in the context of student engagement during the workshop. Most students expressed a positive inclination towards the designed activities within the workshop setting.

The use cases for conversational AI tools, exemplified by tool, extend across various educational scenarios. Notably, students find value in these tools for answering questions and acquiring information. Tool’s ability to respond with both words and pictures enhances comprehension and aids in grasping challenging concepts. Students anticipate utilizing the tool for sourcing information for school assignments and exam preparation. In exam scenarios, the plan is to leverage the tool for generating study questions and summarizing extensive texts, facilitating efficient review before examinations.

Furthermore, students express specific features they would like tool to possess to enhance its utility. These include the incorporation of different types of data, such as importing pictures for assistance with equations and a desire for an expanded repository of math, physics, and chemistry formulas. Students also express the need for sound files to facilitate language learning, as well as features like diagrams, charts, technical capabilities, auto scroll functionality, and progress tracking. An educational feature that adapts and instructs using specific sources is highlighted as a valuable addition. However, concerns are raised regarding the fear of diminishing innovativeness and the potential replacement of manual tasks, leading to job scarcity in the future.

A prevalent fear among students is the perception that AI tools like tool might replace human efforts, making manual tasks obsolete and potentially impacting the labor market. There is apprehension about overreliance on AI, potentially leading to decreased critical thinking and a reliance on tools for every aspect of learning. Concerns also extend to potential unfairness, with worries about cheating and job displacement. Some students fear that teachers may lose trust in students due to the availability of AI tools, leading to a reduction in assignments and tests. Overall, while students acknowledge the benefits of conversational AI tools like tool, these concerns underscore the need for careful consideration of the implications and responsible integration of such tools into the educational landscape.

Observation while teachers using ChatGPT as a tool.

ChatGPT presents versatile use cases in the realm of education, notably in lesson planning and data gathering, enhancing efficiency in various aspects of teaching. Teachers can leverage ChatGPT to summarize information, providing simpler explanations for students struggling with translation due to different home languages. It proves valuable in creating lesson plans and offering suggestions for tasks. The tool also plays a role in teaching by correcting grammar generated by AI, serving as a quick check to gauge student learning.

The advantages of employing ChatGPT in an educational context are evident in its efficiency and time-saving capabilities. Teachers can swiftly generate learning questions for students, utilizing ChatGPT as a teacher assistant to streamline tasks and save valuable time. However, it is crucial to acknowledge certain disadvantages, including concerns about credibility as the tool's responses are not scientifically proven. The potential for incorrect answers raises reliability issues, necessitating careful data analysis to verify information before use. Ethical considerations emerge, with fears that the tool might stifle innovative thinking by promoting a desire to save time rather than fostering critical thought processes. Despite these drawbacks, the advantages of efficiency and time-saving underscore ChatGPT's potential as a valuable tool in the educational landscape.

Observation while teachers using AI4EDU prototype as a tool.

The designed activities have garnered positive feedback from all teachers, indicating a favorable reception. Regarding the utilization of tool in various aspects of their work, both within and beyond the school setting, teachers express intentions to employ it extensively in lesson planning, summarization, and as a teacher assistant. In the context of lesson planning, teachers see the tool as a valuable resource to assist in planning, summarizing information, and creating engaging materials such as slideshows and assignments. As a teacher assistant, the tool is anticipated to facilitate explanations in diverse ways, adapting responses to suit the individual needs of students. The tool is seen as particularly beneficial for summarizing lengthy texts, easing the creation of exercises, questions, and explanations at varying difficulty levels.

What were the main points raised by the teachers as to how they think that the Teacher Mate is going to be helpful for them?

Teachers: Teachers were really excited about Teacher Mate. They saw how it could help with their work by making lesson plans and tests. This was a big relief because these tasks take up a lot of time. Teacher Mate seemed like a time-saver, giving teachers more time to focus on students. However, teachers also had worries. They wondered if Teacher Mate could handle subjects where students need to think creatively and critically. These are important skills that we teach our students, and teachers weren't sure if Teacher Mate could understand them. Teachers agreed on something important: while Teacher Mate could help with ready-made prompts, it cannot replace the special connection between a teacher and their students.

Teachers do much more than just give information – they guide, mentor, and understand each student's unique needs. Teacher Mate might provide materials, but it cannot offer the personal touch that a teacher gives in a classroom.

So, teachers were happy about the help Teacher Mate could provide, but they also wanted to get better at understanding the deeper parts of teaching. They believe in using tools like Teacher Mate to support their work, but they want these tools to work alongside their teaching skills, not replace them.

What were the main points raised by the teachers as to how they think that the Study Buddy is going to be helpful for their students? What did students think?

Teachers emphasized Study Buddy's potential to enhance students' research skills and promote engagement. They recognized its ability to stimulate interest and activate students' attention, reflecting a positive outlook on its impact. However, as per the Sample Questionnaire, teachers also expressed concerns about over-reliance on technology, indicating a need for a balanced integration where Study Buddy supports learning without replacing critical thinking and active participation.

Students: While students interacted with Study Buddy, their responses primarily focused on the positive aspects of AI engagement. They highlighted Study Buddy's potential to simplify homework, gamify learning, and help in understanding complex concepts.

Which features would they like to be integrated in conversational AI apps?

Teachers: Teachers showed a clear understanding of AI's potential. They expressed the need for AI apps to cater to diverse learning needs, such as special education requirements, and to provide reliable information while integrating with existing educational materials. Their emphasis on features like image creation, scientific validity, and interaction with multiple textbooks underscored the importance of practical functionalities that enhance the learning experience.

Students: Given their exposure to Study Buddy, students would appreciate features that make learning more interactive and visually engaging, such as interactive images, importing their own sources, gamified learning scenarios, and real-time feedback.

What challenges do they face today that they envision this technology can help them address?

Teachers: The challenges faced by teachers are multifaceted. From creating quality lesson plans to enhancing students' research skills, more and more teachers are gradually starting to seek AI solutions to simplify complex tasks, save time, and engage students effectively. The need to balance workload while ensuring a high standard of education.

Students: While students might not explicitly mention their challenges, they would appreciate AI's role in making learning more interactive and tailored to their individual needs.

What were the main fears expressed by teachers regarding the use of AI for teaching and learning?

Teachers: The fears expressed by teachers reflect concerns about the societal impact of AI adoption. They fear the potential social inequalities arising from technology disparities among schools. Additionally, concerns about students' lack of critical thinking and over-reliance on AI indicate teachers' worries about the long-term effects of AI on education. These concerns underline the need for a cautious approach, ensuring AI integration complements, rather than replaces, essential skills.

Students: Students worry that too much reliance on technology might make us lose our real connections with people. "We're afraid it could affect our creativity and critical thinking because talking and learning from real people is super important." Also, "we're not totally convinced about AI because sometimes it might not give the right answers, and it's easy for wrong information to spread." "We want to make sure we're learning things correctly, you know? But hey, we're also kind of glad to have a tool that helps us with our everyday homework."

Are there any changes observed between first and last workshops regarding teachers' opinions towards AI?

Teachers: The data from the events does not indicate significant changes in teachers' opinions. Teachers maintain a skeptical yet open-minded attitude. They are receptive to AI's

possibilities but remain cautious, emphasizing the importance of appropriate training and implementation.

Having conducted the workshops, how confident do you believe teachers are today around the utilization of AI tools in their daily lives? / Primary takeaway

Teachers display a willingness to learn about AI but lack confidence in its widespread use. They recognize the need for appropriate training and express concerns about students' over-reliance on technology. Their primary takeaway is the necessity for comprehensive training programs that address both teachers' and students' needs, ensuring effective and responsible AI integration in education. Students' primary takeaway is the excitement about AI's possibilities and an awareness of its mistakes and limitations.

Teachers are not very confident but are willing to learn about it and about using it effectively. They are skeptical about the negative impact on students because of over-relying on technology and not being able to identify inaccuracies and false information in AI's output. They all pointed out the need for teachers and students to be trained for the appropriate and effective use of AI.

Students recognize AI's potential to enhance their learning experiences but also acknowledge the importance of maintaining human interactions with their teachers and colleagues.

Suggestions for the Teacher Mate by the teachers.

Teacher Mate could offer educators the ability to customize educational content, including lesson plans, quizzes, and interactive materials, supporting creation of multimodal learning materials. Educators could develop content incorporating text, audio, video, and interactive elements, catering to diverse learning preferences and enhancing student engagement. Concurrently, teacher Mate could analyze students' performance data and recommend specific teaching resources, educational apps, and multimedia content to address individual learning gaps. These tailored suggestions can assist educators in providing targeted support. This may include integrated assessment tools that dynamically adjust the level of difficulty based on students' performance.

Suggestions for the Study Buddy by the students.

Students want Study Buddy as an interactive learning companion who uses natural language processing to answer questions, provide explanations, and offers feedback in a conversational manner. "A hologram could also be useful," a student said. Study Buddy could also be used to generate personalized study plans, ensure focused revision, and summarize key concepts of the (enormous in most cases) textbooks. It could also incorporate gaming elements such as quizzes, rewards, and leaderboards, transforming a boring lesson to an engaging and competitive experience.