# Artificial Intelligence in Higher Education: A Roadmap and Future Perspectives

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This paper introduces a novel roadmap for best understanding the connections and impact of Artificial Intelligence (AI) in Higher Education (HE). It draws on insights from nine AI in HE case studies, from Denmark, Portugal and the United Kingdom, collected in an ERASMUS+ funded project. The roadmap builds on the model "learning *with* AI, learning *about* AI, and preparing *for* AI" developed by Holmes et al. (2019); and describes "developments, enablers and disablers," for the "now, next and later" of AI and HE. We also illustrate the roadmap with the input of expert workshop participants and point to its future use to support researchers, developers and teachers on the connections between AI and HE.

## 1. Introduction

The potential of Artificial Intelligence (AI) has taken a long time to be exploited. In fact, many recent advances are yet to reach widespread use. Nonetheless, AI-powered systems are increasingly being deployed in schools, colleges and universities, as well as in corporate training around the world. While many people fear that AI in education means robot teachers, the reality is less dramatic but potentially still transformative. The connection between AI and education is also more complex than is often assumed. At the very least, it involves learning *with* AI, learning *about* AI, and preparing *for* AI (Holmes et al., 2019). Learning *with* AI (often known as "Artificial Intelligence in Education" or "AIED") involves student-facing applications of AI (such as the so-called intelligent tutoring systems, dialogue-based tutoring systems, exploratory learning environments, automatic writing evaluation, and conversational agents), system-facing AI (for recruitment, timetabling and other back-office applications), and theoretically at least teacher-facing AI (although there appear to be currently few such examples). Meanwhile, the connection between AI and education also involves learning *about* AI (how AI

works and how to create it) and preparing *for* AI (the impact of AI on humans, raising issues such as biases, fairness, and surveillance).

For Higher Education (HE), learning *about* AI has long been a focus, with many data science, coding and AI courses offered by the Computer Science and Science, Technology, Engineering and Mathematics (STEM) departments in most HE institutions around the world. AI is also increasingly being used in HE for automatically profiling students and predicting student outcomes, as well as for assessment and evaluation. Similarly, a few HE institutions are also using adaptive systems, such as the so-called intelligent tutoring systems, with the aim of (although not necessarily the reality of) personalising course offerings to individual students (Zawacki-Richter et al., 2019).

However, meanwhile, there appears to be little focus by HE institutions on preparing their students, or the wider public, for the growing impact of AI on humanity – a role that it could be argued HE institutions should readily adopt. What does it mean to live in a world in which AI is increasingly present, is affecting jobs, and might be laden with biases and be unfair or untransparent? Instead, most AI research focuses on using quantitative experiment to determine whether the AI 'works' and how it might be 'improved', while there is little research into the impact of AI-powered student profiling, automated assessments, intelligent tutoring systems, or other uses of AI in HE on HE students and teachers. In particular, there appears to have been little effort to understand the present, near future and far future of AI in HE.

This gap is something that we aimed to address as part of an Erasmus+ project, entitled "Artificial Intelligence in Teaching" (AIT) (2019-1-DK01-KA203-060293). In particular, our work set out to support decision-makers, educators, learning scientists and other stakeholders to better understand and engage more productively with the emerging connections between AI and HE. We began with nine case studies of AI in HE applications in Denmark, Portugal, and the United Kingdom[13]. An analysis of the nine case studies found that all could be categorized as "learning *with* AI," of which five could be described as so-called intelligent tutoring systems. We also conducted a large

[13] https://drive.google.com/drive/folders/1A_08TY-zImFU9V4-kEahqjmFk6dds-Dn?usp=sharing

number of interviews with AI-HE experts in the three same countries. The case studies and interviews together revealed that the evidence about the development of AI in HE was confusing. Accordingly, we aimed to develop a simplified picture, categorizing the available information about the connection of AI and HE. Drawing on the project's review of multiple roadmaps and related approaches, a novel roadmap for the connections between AI and HE was devised (Figure 1).

## 2. Developing an AI-HE roadmap

Based on our case study data, and a review of various roadmaps and related approaches, the AI-HE roadmap was designed (Figure 1). The roadmap brings together two key dimensions: first, the learning *with* AI, learning *about* AI, and preparing *for AI* classification (Holmes et al., 2019); and second, a time-related wide lens divided into *now*, *next* and *later*. To this was added four arrows to indicate key actors involved in the ongoing and future development of AI in HE.

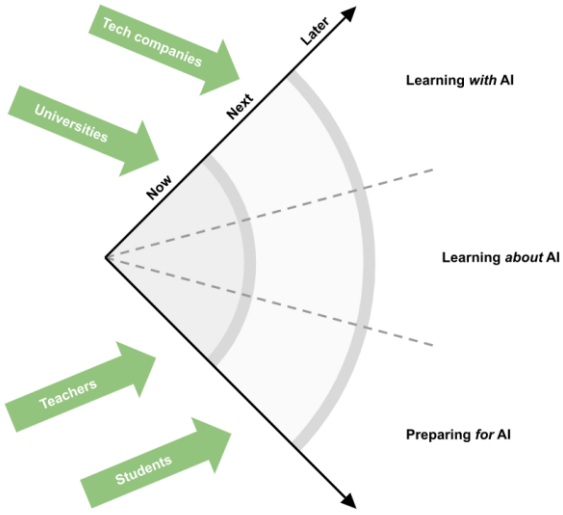


Figure 1: *AI-HE roadmap template*.

Having established the roadmap, the next step was to populate it with relevant information. To achieve this, at the AIT project's final international multiplier conference, we invited participants (a total of 9 AI and HE experts from 3 countries) to contribute their insights. Due to COVID-19 restrictions, the conference was held online, using the video conferencing system Zoom.[14] Participants were randomly divided into three groups, one for each segment of the framework (learning *with* AI, learning *about* AI, preparing *for* AI). The three groups then discussed, each in their own separate breakout room and moderated by a member of the AIT research team, the following topics: (i) AI and HE, (ii) the two dimensions of the roadmap ("about," "with," and "for," and "now," "next", and "later"), (iii) their implications, and (iv) a third dimension: "developments" (what is being/will be developed), "disablers" (what is preventing those developments), and "enablers" (what is enabling those developments). Participants then contributed their insights to the roadmap using the 'post-it note' and 'comment' facilities of the Miro collaborative whiteboard platform.[15] Finally, the resulting whiteboard (Figure 2) was summarised and analysed to create Table 1.

[14] https://zoom.us/
[15] https://miro.com/

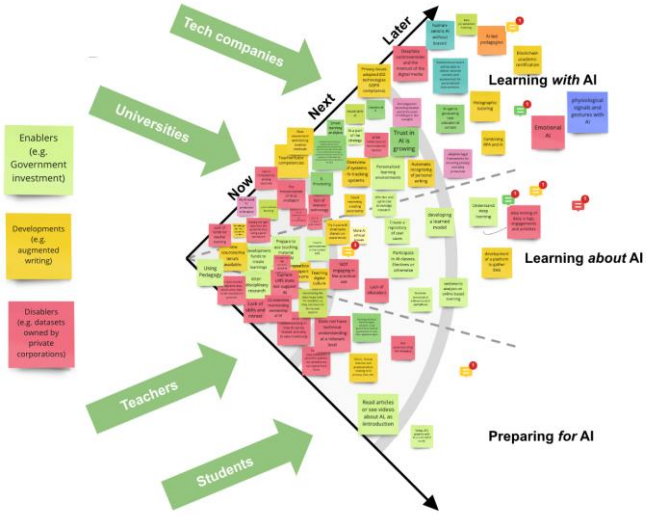


Figure 2: *AI-HE roadmap template completed by AIT multiplier event participants*.

## 3. The AI-HE Roadmap

Table 1 represents a summary and analysis of the AI-HE Roadmap as completed by AIT multiplier event participants. It identifies multiple issues in terms of the three dimensions: (i) learning *with* AI, learning *about* AI, and preparing *for* AI; (ii) now, next, and later; and (iii) developments, disablers, and enablers.

| | LEARNING *WITH* AI | LEARNING *ABOUT* AI | PREPARING FOR AI |
|---|---|---|---|
| NOW<br>Developments | • Information on algorithms, standards and benchmarks<br>• Integration of AI in test modules in HE<br>• Adoption of current platforms (IBM Watson, AWS AI, Google AI Platform, Microsoft Azure Cognitive Services)<br>• Data-driven methods for assessment (including e-proctoring)<br>• Learning analytics dashboards being adopted across institutions<br>• Peer-supported digital environments becoming the norm<br>• Use of machine preparing for dropout prediction and flagging for interventions<br>• Automated captioning of live video lectures<br>• OCR and automatic recognition of handwriting | • Teacher's training on AI platforms (IBM Watson, AWS AI, Google AI Platform, Microsoft Azure Cognitive Services)<br>• Open learning courses on AIED (MOOCs, OER) | • Integration of AI Ethics in test modules for teachers and students in HE<br>• Guidelines for AI Ethics to be used by research teams<br>• Creativity for AI; modelling the future instead of just predicting it<br>• Increasing interest around AI by school-age (even if with a sci-fi slant)<br>• Growth in interest in computer science as a career choice |

| | LEARNING *WITH* AI | LEARNING *ABOUT* AI | PREPARING FOR AI |
|---|---|---|---|
| NOW Disablers | • GDPR restrictions<br>• Political and regulatory measures<br>• Obsolete laws<br>• Economic crisis (post-pandemic) widening the gaps in adoption<br>• Misconception of AI as truly intelligent (and overriding human decision-making)<br>• Biased AI, trained with imbalanced data<br>• Current insufficient awareness of AI, leading to mistrust<br>• Lack of strategic governance and investment in technology<br>• Limited competencies on AI amongst educators | • Economic crisis (post-pandemic)<br>• Lack of fund for teaching training and slow adaptation of content for teachers<br>• The perception (and reality) of it being an additional burden in practice for time-strapped teachers<br>• Innovation adoption being challenging for some teachers<br>• Poor/non-existing integration of current LMS with AI | • Economic crisis (post-pandemic)<br>• AI developments being solely "owned" by computer scientists solely as multi-disciplinarity is rarely well rewarded<br>• Lack of domain knowledge by those developing AI systems now<br>• Lack of diversity in developing teams, and even in captured data, leading to a lack of awareness of biases in AI<br>• Too high expectation of what AI can do or can be expected from it |

| | LEARNING *WITH* AI | LEARNING *ABOUT* AI | PREPARING FOR AI |
|---|---|---|---|
| **NOW** Enablers | • Greater processing power, connectivity and affordability of devices (e.g. ARM processors, 5G networks)<br>• Implementation of HE models for data handling: student supervision and assessment through AI (dashboards, algorithms, benchmarks, standards)<br>• Learning analytics frameworks | • Information campaigns and establishment of large ecosystems<br>• Curriculum for non-computer science students, teaching key AI technologies, approaches, and issues<br>• Wide availability of materials for learning about AI (e.g. MOOCs)<br>• Inter-disciplinary research<br>• Growing research interest around explainable AI | • Completion of a micro-credential's curriculum for all EU citizens<br>• Automation of data-heavy tasks for teachers, so that they can focus on the pedagogy and the human aspects |

| | LEARNING *WITH* AI | LEARNING *ABOUT* AI | PREPARING FOR AI |
|---|---|---|---|
| **NEXT Developments** | • Developments:<br>• Framework for Digital Transformation in HE, with AI being included as part of the strategy<br>• Common standards for AIED across the EU<br>• VR and AR meet AI<br>• Use of machine preparing for grade prediction and much more timely interventions<br>• More accurate mechanisms for e-proctoring and development of suitable assessment methods for remote learning<br>• Data from tracking systems (e.g. for attendance and use of resources) incorporated into dashboard solutions | • Developments:<br>• Widespread, accessible training with micro-credentials and MOOCs about AI<br>• VR and AR tools in training<br>• Chatbots and collaborative tools support training<br>• Growth in trust and familiarity with AI<br>• AI literacy as part of data literacy<br>• Integration of AI capabilities into LMSs, including help on interpretation of recommendations<br>• Sentiment analysis on online-based learning | • Developments:<br>• Training on computational creativity<br>• Learning computational and robotics ethics |

| | LEARNING *WITH* AI | LEARNING *ABOUT* AI | PREPARING FOR AI |
|---|---|---|---|
| NEXT Disablers | • Clash of global commercial interests with EU policy<br>• Technological capitalism and over-dependency on big-tech for solutions that may not be suitable for teaching and learning<br>• Mistrust of digital media arising from deep-fake controversies | • Rising complexity of learning about AI | • Rising screen isolation |
| NEXT Enablers | • Humanistic EU approach to AI in HE<br>• Blockchain academic certification<br>• Incorporation of privacy-sensitive mechanisms for dealing with data (adopted for GDPR compliance and equivalent frameworks elsewhere other than the EU)<br>• Dispositional AI and affective computing<br>• A shift in acceptability of computing for learning (post-COVID) | • Funding initiatives to support development and integration of AI into education (at local, national and international scale)<br>• Community engagement | • Truly personalised learning (i.e. personalized outcomes, not just personalized pathways) |

| | LEARNING *WITH* AI | LEARNING *ABOUT* AI | PREPARING FOR AI |
|---|---|---|---|
| LATER Developments | • Teaching personalization, for tailored learning content and assessment<br>• AI-powered virtual tutors<br>• AI-powered adaptive learning<br>• Tailored smart e-books<br>• Computer vision + AI<br>• Development of AI-driven pedagogies<br>• Detection of physiological signals and gestures with AI for emotional computing | • AI authoring tools for teachers | • AI transformation of society at large |
| LATER Disablers | • Security and privacy issues<br>• Reliability of complex models | • AI Knowledge too complex; mainly restricted to ethical and moral issues | • Dealing with job loss due to widespread use of AI<br>• Low income jobs rising |

| | LEARNING *WITH* AI | LEARNING *ABOUT* AI | PREPARING FOR AI |
|---|---|---|---|
| LATER Enablers | • Quantum computing<br>• Justice and bias detection<br>• Autonomous tutoring systems<br>• Smarter robots through AI<br>• Adaptive legal frameworks for ensuring privacy, consent and data protection | • Training for new work areas<br>• Open platforms | • Learning new skills for professional conversion |

Table 1. *AI-HE roadmap: developments, disablers and enablers*.

## 4. Outcomes of the AI-HE Roadmap Table

Drawing on our nine case studies and our interviews with AI-HE experts, we drafted a detailed AI-HE roadmap table (Table 1). The table is based on the AI-HE roadmap, and includes the "learning *with*, learning *about* and preparing *for*" categorization, the "now, next, later" temporal dimension, and the considerations: "developments", "enablers" and "disablers". The key contribution of this paper is the roadmap itself. The issues raised in the workshop and summarised in the table probably represent only the tip of the iceberg. Further research is now needed for a more nuanced and in-depth understanding of the now, next and later of AI in HE.

Key now developments mentioned by participants under "learning *with* AI" included adopting existing platforms and using AI in learning analytics. Under "preparing *for* AI", participants mentioned that some research is currently being conducted into integrating ethics into AI, and that there also appears to be a growing interest in computer science as a career choice. Under "learning *with* AI", participants mentioned that some of the most important disablers include GDPR restrictions, obsolete legislation and a lack of AI competencies among teachers. Meanwhile, under "preparing *for* AI" participants suggested that one of the most important disablers is the lack of a coherent multidisciplinary approach. On the other hand, enablers included a rising awareness of AI in HE and an increasing range of curricula and materials for learning *about* AI.

Key next developments mentioned by participants under "learning *with* AI" included the development of common standards for AIED in the EU and the controversial use of machine preparing for grade prediction. Under "learning *about* AI" participants predicted that VR and AI will increasingly be used together. In addition, participants mentioned a growing interest in AI literacy. Similarly, under "preparing for AI," participants predicted that learning computational and robotics ethics will become increasingly important. Also under "learning with AI," participants suggested that an important disabler is

likely to be a clash with "Big Tech" (i.e. companies such as Google and Facebook). However, there also seems to be a number of enablers. Participants mentioned that the most important enablers for "learning *with* AI" and "preparing *for* AI" included the "humanistic" approach to AI in HE being adopted by the EU and UNESCO (Miao and Holmes, 2021), and the potential use of blockchain to underwrite academic certifications.

Key **later** developments under "learning with AI" speculated by participants included the possibility of teacher personalization, AI-powered virtual tutors and the detection of physiological signals during learning. Under "learning about AI," participants speculated the possibility of AI authoring tools for teachers. Probable disablers under "learning with AI" included security risks and privacy issues. Meanwhile, under "preparing for AI", and the fact that we might have to deal with job losses due to the use of AI was also mentioned. Finally, under "learning with AI" participants suggested enablers such as quantum computing, and under "learning about AI" the need for training for new work areas.

## 5. Now Developments: an example

Finally, we give one exemplar "now development" which to some extent addresses all three AI and HE connections ("with," "about," and "for"). This is the "AI in Business Economics" project (Figures 3 and 4) developed by the AI-EØ project group in Denmark, which is one of the nine cases in the AIT project (see also Sørensen and Hultberg in this anthology). The AI in Business Economics Project firstly focuses on "learning *with* AI." It developed six student packages that can be accessed by teachers and students and used as cases in the business economics classes. The student packages also to some extent include "learning *about* AI," as they also feature modules introducing machine learning, deep learning and neural networks, clustering, regression algorithms and data preparation. Some modules are shown in Figure 3.


Figure 3: Selected Packages on AI in the AI in Business Economics Project.

Finally, the AI in Business Economics project also includes "preparing *for* AI," as it also offers digital learning modules introducing relevant philosophy and ethics, ethics of duty, utilitarianism and virtue ethics to prepare both teachers and students for the ethical implications of using AI for different purposes. Some of these modules are shown below in Figure 3.


Figure 4: Selected Packages on Ethics in the AI in Business Economics Project.

The six student packages and two teacher-oriented packages in the AI in Business Economics project are, at the time of writing, being tested by students and teachers at the eight Danish Universities of Applied Science and Copenhagen Business School. Results to date have been very encouraging and will be reported in detail later.

## 5. Conclusion

In this paper, we have offered a novel roadmap, which we have illustrated with expert perspectives on AI in HE. The roadmap was developed by the AI-T Erasmus+ project, and involved nine comprehensive case studies and interviews with AI and HE experts, from three countries (Denmark, Portugal, and the United Kingdom).

As we noted, the key contribution of this paper is the roadmap itself (Figure 1) – which combines the "learning with AI", "learning about AI" and "preparing for AI" classification (Holmes et al., 2019), the "now, next, later" temporal dimension, and the "developments", "disablers" and "enablers" considerations. We hope that others will find the roadmap useful to help them better understand and enhance the connection between AI and HE (in research and teaching).

The issues raised by workshop participants (Figure 2) and summarised in Table 1 are wide ranging and thought-provoking, but they probably represent only the tip of the iceberg of possibilities and implications. In addition, some are controversial and others possibly overly-optimistic. Accordingly, further research is now needed to enable a more nuanced and in-depth understanding of the now, next and later of AI in HE. Nonetheless, we argue that the roadmap can be used to frame and help analyse existing and future research in AI in HE. By creating a strategic overview of the existing and potential developments, enabler and disablers, the aim is to enable researchers and developers to develop, in liaison with teachers and other stakeholders, AI tools that best serve the HE learners of today and tomorrow.

In addition, as well as their well-established work teaching about AI, it is hoped that HE institutions will also carefully consider their roles in helping prepare all their students, indeed all citizens, for a future in which AI is ubiquitous and has complex, wide-ranging and profound implications.

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