Propagating AI Knowledge Across University Disciplines- The Design of A Multidisciplinary AI Study Module

Samuli Laato
Dept. of Future Technologies
University of Turku
Turku, Finland
sadala@utu.fi

Henna Vilppu
Dept. of Teacher Education
University of Turku
Turku, Finland
henna.vilppu@utu.fi

Juho Heimonen
Dept. of Future Technologies
University of Turku
Turku, Finland
juho.heimonen@utu.fi

Antti Hakkala
Dept. of Future Technologies
University of Turku
Turku, Finland
antti.hakkala@utu.fi

Jari Björne
Dept. of Future Technologies
University of Turku
Turku, Finland
jari.bjorne@utu.fi

Ali Farooq
Dept. of Future Technologies
University of Turku
Turku, Finland
ali.farooq@utu.fi

Tapio Salakoski
Dept. of Future Technologies
University of Turku
Turku, Finland
tapio.salakoski@utu.fi

Antti Airola
Dept. of Future Technologies
University of Turku
Turku, Finland
antti.airola@utu.fi

***Abstract*—The on-going AI revolution has disrupted several industry sectors and will keep having an unprecedented impact on all areas of society. This is predicted to force a major proportion of the workforce to re-educate itself during the next few decades. Consequently, this has led to a growing demand for multidisciplinary AI education also for students outside computer science. Therefore, a 25 credit (ECTS) cross-disciplinary study module on AI, targeting students in all faculties, was designed. We present findings from the design and implementation of the study module as well as students' initial perceptions towards AI at the beginning of the study module. Enrollment for the first implementation of the study module began in autumn 2019. The student distribution (N=144) between faculties was the following: natural sciences (n=37), social sciences (n=23), law (n=17), education (n=17), economics (n=16), medicine (n=10), humanities (n=10) and open university (n=14). Based on a survey distributed to students (N=34), the primary reason for enrolling to study AI was interest towards the subject, followed by the need of AI skills at work and relevance of AI in society.**

***Index Terms*—AI, study module, Cross-disciplinary, multi-disciplinary, education**

I. Introduction

Simultaneously with increased availability of data, solutions that make use of the data have flourished [1]. At the forefront is AI, primarily machine learning. AI can be used to automate processes and replace human employees in several industry sectors such as logistics, agriculture [2] and medicine [3], but it can also be used to solve complex and otherwise difficult problems. The magnitude of the impact AI is predicted to have, and already has, on society, has been compared to the industrial revolution [4]. One of the concerns is that AI solutions will birth greater inequality as they allow replacing workforce with machines, which will lead to increasing wealth for the bourgeoisie and unemployment to the poor and the middle class.

However, the impacts of the use of AI do not limit to replacing human workforce with machines, in fact the impacts are predicted to be holistic [1]. A few examples of common AI provided technology include internet search engines [5], traffic accident prevention solutions [6] and realistic AIs for video games with imperfect information [7]. However, AI solutions are not without error as, for example, certain AI used in courts to evaluate defendants likelihood of committing future crimes have been found to exhibit racial bias [8]. Such misjudgements may arise in machine learning solutions either because of the learning algorithms or the training data. It follows that the changes AI has on society are (1) ubiquitous; (2) unprecedented; (3) not self-evident; and (4) complex. Accordingly, basic education on AI, how it works and where it is being used, needs to be accessible to all citizens. This can be seen even as a requirement for democracy as algorithmic and data driven electoral campaigning has become prominent, and society as a whole needs to be aware of these options to be able to make informed policies and regulations to ensure democratic elections can be held in the future [9].

Typically AI education is limited to to computer science majors with occasional courses offered in other disciplines. Furthermore, the content of the teaching (e.g. [10]) is highly technical with little emphasis on the ethical, societal or cultural implications of the use of AI. Because of the impressive feats of modern AI solutions across sectors, interest towards it is predicted to have been generated in all disciplines. Furthermore, other disciplines besides computer science could greatly benefit from knowledge on AI. For these reasons we decided to design and implement a 25 credit (ECTS) truly multi-disciplinary AI study module and offer it to students in all disciplines.

This study represents the design process and implementation of this study module as well as preliminary results from students taking the course, focusing on their perceptions about AI and reasons for enrolling to the study module. Using data from the design process and a survey (N=34) sent to students, this paper addresses the following research questions:

- **RQ1:** *How should a multi-disciplinary AI module for all disciplines be structured?*
- **RQ2:** *Are students across university disciplines interested in multi-disciplinary AI education?*
- **RQ3:** *What were the main reasons for students to enroll to the study module?*
- **RQ4:** *What are the initial perceptions and attitudes study module students have regarding AI?*

II. Background

In this section we review relevant literature on AI education in order to determine what aspects of AI should be included in a multi-disciplinary AI study module. We also discuss which pedagogical approaches are effective in this sort of a study module to establish a reference point for evaluating the study module. Finally, we discuss literature on students' initial knowledge on AI when they enroll to the study module. This is done to enable effective understanding of the motivation and initial skills of enrolled students.

A. What is meant by AI? Defining Key Terminology

AI is a broad term that lacks a universal semantically unambiguous definition. The primary reason is that humans do not agree on how to define intelligence [11]. One of the widely used definitions for intelligence comes from Stenberg: Intelligence comprises of *"the mental abilities necessary for adaptation to, as well as selection and shaping of, any environmental context"* [12]. It then follows that when a machine is capable of adapting to its environment, and of selecting and shaping it, it is intelligent, and hence, we can call it AI. But AI historically has been used to describe also algorithmic decision making (e.g. [13]) which might not be intelligent according to Stenberg's definition. Due to the broad meaning that AI has, some scholars have proposed and used alternative terms to describe artificial human-like intelligence such as term machine intelligence [14] or digital intelligence [15].

Despite not having a universal clear definition of AI, the term is still preferred in practise over more accurate terms such as machine learning [16], deep learning [17] or cooperative intelligence [18] when discussing the social impact of the above mentioned tools. AI researchers have been found to favor definitions which emphasize technical functionality, whereas policy makers tend to compare these systems to human thinking and behavioral patterns when defining AI [19]. The reason is that when discussing the social impact of AI tools, the underlying technology becomes less significant [19]. Accordingly, in the current study we use the term AI, as we are concerned mainly about the implications rather than the technical details.

B. What Aspects of AI Should be Taught

As AI solutions are being integrated to everyday lives via smart technologies and IoT, it is no longer a narrow area of technology, but a growing part of businesses and products. It is beneficial for individuals to know the basics of AI on the technical level to support understanding of the implications of AI on societal, economical and cultural levels. One of the recent calls for multi-disciplinary education has argued that a lack of understanding between disciplines may lead to technical and regulatory mistakes in areas where co-operation is needed [20]. And indeed, following the technical development of AI solutions legislators, educators, manufacturers and countless other stakeholders are involved with AI systems.

A seminal AI education book by Russell and Norvig consists of seven main parts: (1) introduction to AI; (2) problem-solving; (3) knowledge, reasoning and planning; (4) uncertain knowledge and reasoning; (5) learning; (6) communicating, perceiving and acting; and (7) conclusions [10]. The book is aimed at computer science students and includes programming examples and exercises which albeit necessary, can be difficult for students outside computer science to understand. A toned down version of the book could still act as a starting point for AI studies, as it takes a solid understandable bottom-up approach that ensures students know what they are working with when engaging with AI. Afterwards courses on applications of AI could be introduced such as AI in medicine, AI in humanities and AI ethics.

Williams argues in a published collection of ideas for AI education, that one of the learning goals in AI courses should be educating students on identifying circumstances where a trade-off between an ethical solution and an effective solution is present, and, on reasoning which choice should be made [21]. Furthermore, ethics of AI can be expanded to cover everything from (1) data collection; to its use in (2) training machine learning algorithms; and from there on to (3) uses of AI and its implications on society; and the governance and legislation of this entire process. These relationships are conceptualized and visualized in Figure 1. Ethics of AI is thus extremely broad and even ill-defined by definition. Yet, its relevance and usefulness in AI education should not be understated [22].

Besides ethics, the other aspects shown in Figure 1 are important. Data, and relating to it, data collection, privacy as well as data engineering can be looked at from multiple perspectives. The technical perspective is of course important for practitioners, but also for others for understanding how AI works. The same applies for the actual AI algorithms and solutions. A survey regarding AI educators' perceptions on what aspects of AI they desire the most to include in their courses showed that (1) machine learning; followed by (2) robotics; and (3) knowledge representation and reasoning were the three most popular categories [23]. However, the results might be different if interviewed teachers represented other disciplines than computer science.

Following the technical aspects is the societal implica-

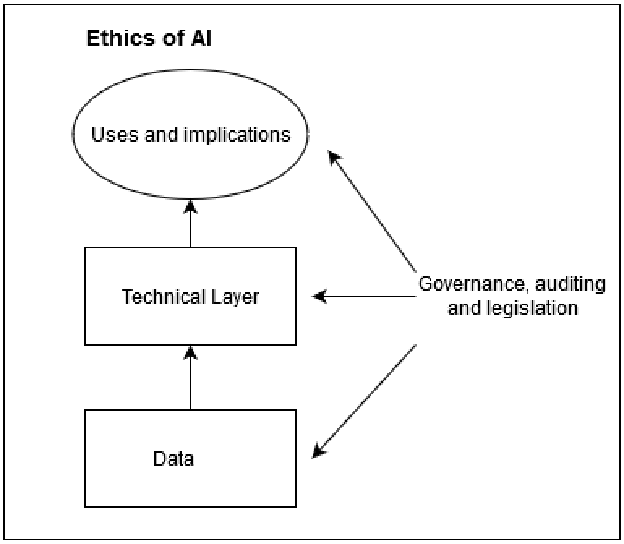

Fig. 1. Conceptualization of the relationships between data, technical implementations, impacts on society, legislation and ethics with regards to AI.

tions of using AI solutions. As previously mentioned, the application areas of AI solutions are already manifold and impossible to cover. Perhaps for this reason more emphasis should be put on the technical tools as similar solutions can be applied in multiple fields. For example, computer vision is being used in self-driving cars for them to make sense of camera data [24], but also in medicine in detecting tumors in medical images [25]. Understanding these solutions enable understanding their capabilities and limitations in real-world contexts. Via focusing on the technical solutions, we avoid the pitfall of overestimating the capabilities of AI and forming an unrealistic perception [19].

Finally, legislation needs to adapt to the age of AI. Currently policy and law makers across the globe are preparing laws regarding self-driving cars, algorithmic decision making and so forth [26]. One of the major questions with regards to AI and legislation is who should be held responsible of AI system failures [27]. An argument can be made that the manufacturer is in charge, but it remains unclear whether this responsibility would carry over if a malicious party attacks these systems [28] or if the AI system is fully autonomous and capable of manufacturer-independent decision-making [29].

To summarize, AI education, even multi-disciplinary, should probably stay close to the technical solutions to ensure an accurate understanding of AI systems, their capabilities and limitations. Additionally, some courses on ethics, legislation and implications AI systems have on society are needed. One of the most widely accepted technical AI study books might be used as a guide for the technical courses [10], but it might be difficult for students from other disciplines to follow. Thus, one of the biggest challenges in a multi-disciplinary AI study module will be how to create technical and relevant educational content on AI that is approachable for non-technically oriented students.

C. *Pedagogical Approaches in AI education*

Pedagogical approaches used in AI education include experiential learning where students are given a platform where they can develop their own solutions and get instant feedback on how it works in a competitive AI environment [30]. Experiential learning has the benefit of relying on intrinsic motivation to learn and boosting it, providing students a fluent transition from learning to doing [31]. In the case of using this approach in AI education, basic education on algorithms and the experiential learning environment is first needed [30]. A close relative to experiential learning is project-based learning, which has been suggested as a strategy to expand discipline boarders in AI education for interdisciplinary learning and innovation [32].

Similarly to teaching any subject, the learning goals of AI courses must be considered when choosing suitable pedagogical approaches. While AI ethics might benefit from conversational exploration of interesting cases [33], technical education on machine learning algorithms should be more focused on learning the necessary skills via a confined environment where the quality of solutions can be objectively assessed. In the case of a large study module consisting of subjects from multiple disciplines a wide variety of pedagogical approaches can be expected to emerge. This can be beneficial for students as it not only serves to deliver a wide range of information, but also challenges to adopt new epistemic beliefs.

D. *Student's Preconceptions Regarding AI*

It is widely accepted that students come to learning situations loaded with pre-instructional conceptions, beliefs, experiences and attitudes (e.g. [34]–[36]). Since new knowledge is built on top of existing knowledge structures, learners filter the phenomena to be studied through their own personal lenses. The quality of prior knowledge is thus one of the most probable predictors of learning (e.g. [37]–[39]). We believe that students' conceptions and beliefs concerning AI are formed through their everyday experiences with computers, smartphones and social media, for instance (cf. [40]). However, higher education students' conceptions on AI seems to be an area that has not yet been studied extensively; rather, studies on perceptions of AI are related to e.g. tourism [41] or people in general [42]. Some research can be found on medical students' attitudes towards AI [43], but we were not able to find any studies which purely concern students' views of AI affecting their lives or their conceptions of the possibilities or risks of AI. Therefore, we wanted to include in this study an explorative investigation on students' prior conceptions concerning AI in the beginning of the multidisciplinary AI study module.

III. Study Module

The idea for the study module was initiated by deans of all faculties at the University of Turku, Finland. Following a top-down approach, the deans got together and decided on creating a multi-disciplinary AI study module and secured funding for its implementation. The responsibility for guiding the implementation was assigned onward to AI researchers with computer science background. We call these researchers the study module facilitators. The facilitators contacted teachers from all faculties at the university, asking about opportunities of what each of them could offer for such a study module. As deans from all faculties were involved, this ensured participation of each of the departments. Chosen teachers from all faculties presented their ideas for a course to the facilitators, who then iterated the design process to ensure no major overlap occurred between courses and the course contents were suitable and realistic for this kind of a study module.

Altogether, eight study disciplines were included. The facilitators presented the final outline of the study module, including course names and learning goals, back to the deans. After incorporating feedback from the deans to the study module design, it was finalized in Autumn 2019 and plans were made to begin teaching in the beginning of 2020. The quality of the study module was thus ensured on three levels: (1) *the deans* supervising the process, (2) *the facilitators* organizing the study module, contacting teachers and ensuring coverage of key topics as well as (3) *the teachers* from eight disciplines who were in charge of the quality of teaching the their topic.

A. Study module courses and disciplines

The facilitators contacted faculty from eight disciplines, and in the end, eight disciplines participated: (1) Computer science; (2) Law; (3) Education; (4) Humanities; (5) Social science; (6) Information systems; (7) Biomedicine; and (8) Nursing sciences. Some of the disciplines were already teaching AI-related courses. Naturally computer science had overwhelmingly the most courses, many of which were highly technical and not suitable for general audience. Upon request, some courses such as *basic methods of AI* and *information system development* were reworked to fit the AI study module. Other courses such as *Introduction to AI* and *Introduction to digital humanities* were included in the study module without any modifications required. Roughly half of the study module courses were completely new and created specifically for the study module.

In order to ensure the study module fit with existing studies at the University of Turku, it was decided to be 25 credits (ECTS) in length, the standard length of a minor subject at the case university. Consequently, the AI study module could be added to undergraduate or graduate studies as a minor subject. Already early on, the facilitators decided to aim for courses accumulating over 25 credits to allow some freedom of choice to the students. The reasoning behind the decision included (1) not all AI courses are going to be suitable or preferable for everyone; (2) some courses might already be included in students' other studies; and (3) it might not be possible for all students from all faculties to schedule to attend all specific courses exactly when they are organized.

The final study module design had the following distribution of offered courses: computer science had the most courses (n=3) followed by law (n=2), social science (n=2) and arts & culture (n=2) and the rest (n=1). The length and scope of the courses varied, with offered credits (ECTS) ranging between 1 and 5. The names of the courses, number of credits offered and responsible disciplines are listed in I. Most of the courses focus fully on AI and its implications, however, the *information system development*, which is the largest course in terms of available credits, included also content unrelated to AI.

The only mandatory course for students was *Introduction to AI*, which aimed to give students a basic understanding of AI, that could act as a prerequisite for the follow up course *Basic methods of AI* that was fixed to be more technically oriented in nature. Both these courses were based on the seminal book by Russell and Nortvig *Artificial Intelligence: A Modern Approach* [10]. The third course included in the module from computer science was *Cybersecurity in AI applications* due to its relevance in peoples' daily actions as well as legal and practical decision making. Also related to the courses offered by computer science is the *Information System and Development* course offered by information systems. It looks at information systems as a whole and how the recent advances in data collection and AI technology has recently changed them.

The aim of the courses provided by the faculty of law is to help students recognize what kinds of problems AI imposes on society from the legal perspective. The courses from the faculty of humanities were designed to illuminate the impact science fiction and popular (miss)conceptions have on public AI discussion and its development as well as demonstrate how humanities can harness AI. The department of education contributed a course that focuses on AI-related thinking skills, primarily computational thinking. Its purpose is to bring attention to and teach the thought processes and mindsets that AI developers have. The two social science courses take a step backwards from concrete problems into a broader picture of AI and its relation to human existence and our ways of thinking. Finally, biomedicine and nursing sciences each offered a course on how AI is being applied in their respective fields and what kind of impact it has on these disciplines. These are the only two courses in the study module which focus on application areas of AI, meaning the majority of the studies consists of building a vast understanding of AI solutions.

IV. Enrolled Students and their Perceptions of AI

In this section we bring in student perspectives by observing: (1) generated interest in the form of number of applicants and how quickly the module study spots were filled after enrollment opened; and (2) open survey responses (N=34) from enrolled students (n=144) on why they chose to study the 25 credit study module.

Enrollment for the first implementation of the study module began in Autumn 2019. Half of the reserved seats were taken within the first minutes the enrollment was open and the rest were filled soon after. The student distribution (N=144) between departments was the following: natural sciences

TABLE I
LIST OF COURSES CONSTITUTING THE STUDY MODULE

Responsible discipline	Course name	credits (ECTS)
Computer Science	Introduction to AI	2
Law	Justice and AI Introduction to the theme	3
Law	Justice and AI Between public and private sectors	3
Education	Computational thinking and 21C skills in teaching and learning	3
Computer Science	Cybersecurity in AI applications	2
Humanities	Introduction to digital humanities	3
Social science	Philosophy and ethics of AI	3
Computer science	Basic methods of AI	3
Humanities	AI and popular imaginary	3
Social science	Universal AI and theories of the mind	3
Information systems	Information system development	5
Biomedicine	AI in diagnostics, pharmaceutics and imaging	2
Nursing Science	AI in nursing sciences	1
Number of disciplines: 8		credits: 36

(n=37), social sciences (n=23), law (n=17), education (n=17), economics (n=16), medicine (n=10), art (n=10) and open university (n=14). Open university refers to students who are not officially affiliated as university students, but who study courses that the university offers outsiders. The fact that reserved minimum seats per each department (n=10) were all filled speaks of the wide interest the module and AI studies have generated.

A. Methods

In the beginning of the study module, students' ideas and beliefs about AI were collected with a survey, consisting of background questions, open-ended questions and a Likert-scale questionnaire concerning perceived impacts of AI [41]. The open-ended questions concerned students' motivation for applying to the module and their ideas about in which situations AI affects their lives. The perceptions and attitudes towards AI [41] questionnaire consisted of 13 items representing benefits of AI, seven items representing risks of AI and seven items representing destructive features of AI. The students answered each item on a Likert-scale from 1 (strongly disagree) to five (strongly agree). Answering to the survey was voluntary, and informed consent was obtained from the participants.

Of all the students, 34 answered the survey, resulting a response rate of 24%. The respondents represented eight faculties, but to guarantee their anonymity, the faculties were grouped into two larger entities: humanities, education, social sciences and Open University (n = 17); medicine, law, economics, and natural sciences (n = 17). The open question asking why students chose to enroll to the 25 credit AI study module was coded with the Strauss and Corbin open coding method [44] and the resulting categories were iterated until reasonable, descriptive and accurate categories were reached.

B. Why students enrolled to the study module

The results of the open coding and frequency of answers are depicted in 2. The most popular reason for enrolling was general interest in AI (n=19), followed by AI supporting current work or existing studies (n=12) and AI being relevant in modern society (n=8). Surprisingly only two students mentioned the strong future prospects of AI solutions. Perhaps the reasoning behind this was that students perceived AI to already be relevant instead of envisioning an even grander role for it in the future.

When asking students' perceptions on how AI influences their lives, five students, 15% of respondents did not have an idea. 14 students, 41%, gave a few specific examples, such as ads or online chatbots. Some of these answers were broad and ill-defined such as ”smartphones” or ”IoT-devices”. 35% of students (n=12) mentioned that AI is already ubiquitous in especially online technology such as search engines. The rest of the students (n=3) did not believe AI impacted their lives in any significant way. Students who were computer science majors all replied with specific examples and two students who were over 65 years old both said AI does not impact their lives in any way.

C. Students' attitudes towards AI

Since the number of participants was small (N = 34), the factor structure of the perceptions and attitudes towards AI questionnaire could not be verified by factor analysis. However, sum scales of the items were formed on theoretical basis (see Table II). Differences between student groups were examined by non-parametric tests using IBM SPSS Statistics 22 (IBM, Armonk, NY).

When comparing the groups against the sum scales on perceptions on AI, no statistically significant differences were found (see Table III). With the small number of participants this result is not surprising, and expanding the study to a larger number of students is needed. Thus, the hypothesis that computer science students perceive AI more accurately [19] compared to students from non-technical disciplines remains unconfirmed (neither confirmed nor falsified).

V. DISCUSSION

A. Key Findings

We summarize our main findings in the following points:

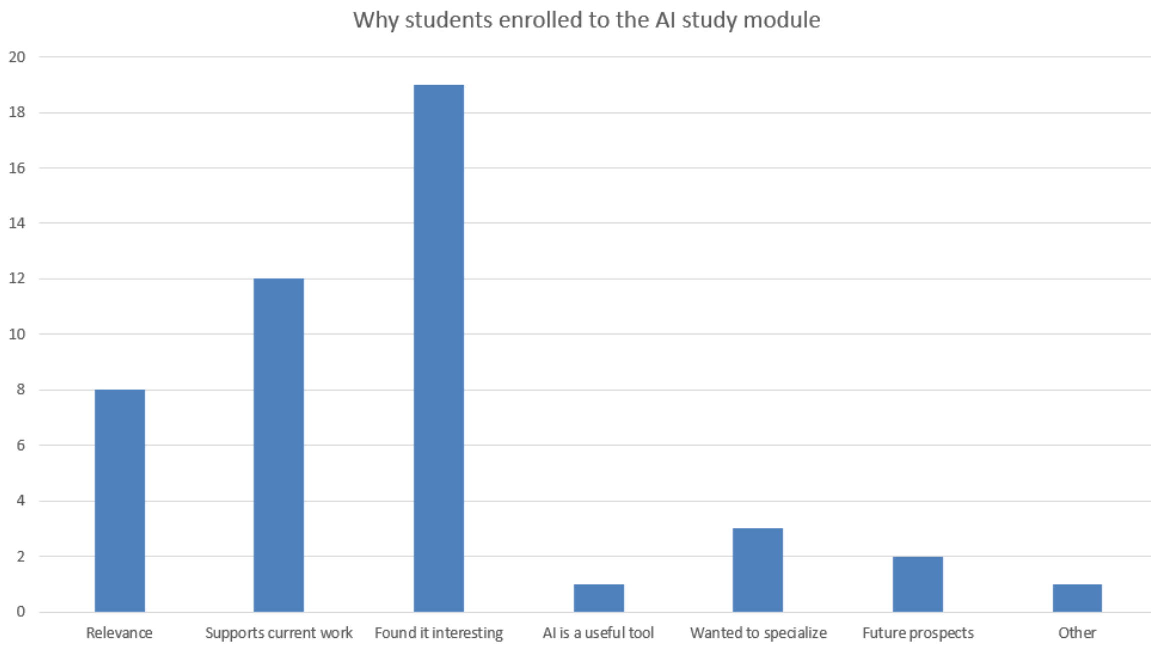

Fig. 2. Resulting categories of open coding and frequencies of students replies on why they enrolled to study in the 25 credit AI study module

TABLE II
SUM SCALES AND EXAMPLE ITEMS OF AI FOR PEBS [41]

Sum Scale	**Cronbach Alpha**	**N of Items**	**Example items:** AI will lead to/bring/provide...
Beneficial AI	0.798	13	...a positive impact on economy
			...products and services that provide greater ease and convenience
Risky AI	0.736	7	...less security of personal data and privacy
			... job losses.
Destructive AI	0.763	7	...harmful impacts on our environment.
			...accidents involving humans.

- There is a need to teach about AI and interest towards AI in all disciplines, not only computer science.
- While a major part of AI education is technical and algorithm-focused, a growing demands exists for more general, societal perspectives on AI such as law, culture, arts and ethics.
- The primary reasons students gravitate towards AI education are: (1) Interest towards the subject; (2) It supports their current employment and employment opportunities; and (3) AI's relevance in current society.
- The preliminary survey data (N=34) showed no significant differences in attitudes towards AI between natural sciences (n=17) and humanities (n=17) or age or gender.

B. Comparison With Other Solutions

MOOCs and online courses are currently the main method for democratizing education as they are able to reach wide audiences asynchronously via the internet [45]–[47]. When attempting to propagate AI knowledge across an entire society, the difficulty level of the content needs to be scalable and adjustable. MOOCs can respond by creating personalized and adaptive study experiences [48], including assisting tools such as a glossary for difficult terminology [49] and offering the possibility to rewind and review course material over and over again. However, there are a few major issues with MOOCS:

- Studies have shown that the MOOCs are mainly being studied by already educated individuals and thus, perhaps the most crucial target audiences of AI knowledge would not find them [46].
- MOOCs have high dropout rates with in many cases over 90% of enrolled students dropping out, even in the most popular online courses [50].
- Online courses are expensive to create but cheap to redistribute, making them ideal for polished content and less ideal for new pedagogical strategies with uncertain outcomes.

For these reasons, a justified starting point for multi-disciplinary AI studies was designing and implementing a smaller scale local study module instead of a MOOC. Furthermore, there already exists high quality MOOCs (including free ones) on various aspects of AI, meaning motivated learners do have access to the material. A smaller case study module designed for university students allows us to iteratively work

TABLE III

GROUP MEANS AND STANDARD DEVIATIONS

Group	n	Beneficial AI M±SD	Risky AI M±SD	Destructive AI M±SD
Faculty				
Humanities, education, social science, open university	17	3,48±56	3.46±67	3.14±69
Medicine, law, economics, and science and engineering	17	3.60±.54	3.57±.78	3.33±.81
Gender				
Women	20	3.54±.55	3.45±.68	3.12±.68
Men	13	3.60±.56	3.55±.76	3.40±.89
Age				
25 or under	13	3.50±.48	3.46±.66	3.03±.71
26-40 years	10	3.87±.44	3.43±.61	3.23±.63
40 or over	11	3.30±.61	3.66±.90	3.48±.88
All	34	3.55±.55	3.52±.71	3.24±.75

on the structure, changing aspects along the way based on teachers' and students' experiences as well as new information from the academic world and industry. Furthermore, via organizing a study module locally, we could investigate whether it generates interest in all departments, just a few or none.

We could not find any scientific publications in similar multi-disciplinary AI education aimed at students from all disciplines. Instead, study disciplines seem to focus on AI each from their own perspective, not co-operating and engaging with each other for mutual benefit. This might be caused by practical reasons, as several universities are organized and governed in such a way which makes collaboration between faculties difficult. For example, there might not exist a method for sharing credit scores between two departments and it might be difficult to schedule courses so that it would fit all disciplines, especially if there are more than five such as in our case. In order to be able to provide such disciplinary-crossing study modules, universities might have to reorganize themselves entirely. With the changing of the society also education must change, which means universities have to change. The changes brought by the COVID-19 pandemic [51] might have further accelerated the processes of change at universities. For these reason reporting findings from these types of study modules is beneficial for understanding the flexibility of universities to adapt to new emerging requirements.

C. Limitations

There are certain limitations in the design process of the study module which deserve to be discussed. First, a lot of responsibility was given to the responsible departments to choose suitable personnel to teach the AI study module courses. This process was most likely influenced by who happened to be available at the departments. Second, some of the study module courses such as *Introduction to AI* already existed beforehand, and these courses were included as such with only minor changes done to make them more accessible to students. This and other similar practical reasons guided the content of the courses. A third limitation is in the design process. Despite the process resembling that which is described in popular design science methodologies (e.g. [52]), no such iterative method could be used due to scheduling limitations. Furthermore, no specific methodology was assigned to the teachers for designing how and what to teach. Instead, teachers were given almost full freedom on choosing how to design and create the content for their courses. Only the learning goals of the courses were checked by the deans and the facilitators. This resembles the way most universities around the world organize their education, meaning that teachers are trusted to be experts on the subject they teach due to their past performance and qualifications and thus, no additional quality assurance is needed. However, through student feedback and checking whether the learning goals are achieved, some insight can be obtained on the quality of the teaching.

The most obvious limitation in the survey sent to students is the low number of responses (N=34). This prevented us from conducting reliable factor analysis on the perceptions and attitudes towards AI instrument [41] and might have also limited the scope of opinions and perceptions received in the qualitatively analyzed open questions. Another limitation comes in the form of the qualitative analysis which was conducted only by an individual researcher, lacking the inter-rater reliability that could have improved the rigour of the process. The reason only a single author was considered sufficient in our case was the type of analysis (open coding [44]) which by nature is quite straightforward, and the reason that we were not looking for highly accurate results, rather a general picture of the reasons why students enrolled to the study module.

D. Future work

The presented work opens several opportunities for future research, as it proposes a novel idea of higher education learning content that unites and spans across all disciplines. It also answers to the calls from previous research [19] to implement multi-disciplinary AI teaching to ensure effective cooperation among stakeholders in AI-related projects. The amount of responses in the initial survey was too low (N=34) for factor analysis but yields interesting preliminary results nonetheless. Future work includes expanding this survey to reach a wider number of students, also from other countries. With regards to the pedagogical impact of the study module, we see three main research opportunities:

- Measure the learning of the students via exams and tests.
- Measure students' conceptual change with regards to AI or specific AI tools with pre and post tests.

- Interview the responsible teachers after the study module to clarify what they feel are the most important aspects of AI for their own study discipline and how well do they perceive they managed to communicate these thoughts.

Organizing study modules aimed at all disciplines in a major university is worth investigating further, as such projects are not commonplace but might be increasingly needed as society moves towards the age of AI.

VI. Conclusions

This work is one of the first to discuss findings from a multi-disciplinary AI study module which covers a wide range of topics across university disciplines. The module generated interest in all departments at our university with seats for the module being reserved quickly after enrollment was opened. The main benefit of this kind of a study module is that it gives a cross-cutting view on how AI solutions impact society. This general view is useful for operating effectively and accurately in a society where AI solutions are increasingly present. Students were mainly motivated to enroll because they had a pre-existing interest in AI and because AI was relevant for their working life and in society. With regards to the pedagogical content of such a module, it was deemed important to ground the studies into the technical reality to ensure students knew what they were talking about when later joining classes on, for example, AI ethics and application of AI in arts and culture. The generated interested towards AI studies that exceeded disciplinary boundaries can be regarded as evidence about the enormous need individuals in modern societies have for AI education.

References

[1] Y. K. Dwivedi, L. Hughes, E. Ismagilova, G. Aarts, C. Coombs, T. Crick, Y. Duan, R. Dwivedi, J. Edwards, A. Eirug *et al.*, "Artificial intelligence (ai): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy," *International Journal of Information Management*, p. 101994, 2019.

[2] H. Tenhunen, T. Pahikkala, O. Nevalainen, J. Teuhola, H. Mattila, and E. Tyystjärvi, "Automatic detection of cereal rows by means of pattern recognition techniques," *Computers and Electronics in Agriculture*, vol. 162, pp. 677–688, 2019.

[3] M. Murtojärvi, A. S. Halkola, A. Airola, T. D. Laajala, T. Mirtti, T. Aittokallio, and T. Pahikkala, "Cost-effective survival prediction for patients with advanced prostate cancer using clinical trial and real-world hospital registry datasets," *International Journal of Medical Informatics*, vol. 133, p. 104014, 2020.

[4] S. Franken and M. Wattenberg, "The impact of ai on employment and organisation in the industrial working environment of the future," in *ECIAIR 2019 European Conference on the Impact of Artificial Intelligence and Robotics*. Academic Conferences and publishing limited, 2019, p. 141.

[5] T. Joachims and F. Radlinski, "Search engines that learn from implicit feedback," *Computer*, vol. 40, no. 8, pp. 34–40, 2007.

[6] A. Iranitalab and A. Khattak, "Comparison of four statistical and machine learning methods for crash severity prediction," *Accident Analysis & Prevention*, vol. 108, pp. 27–36, 2017.

[7] O. Vinyals, I. Babuschkin, J. Chung, M. Mathieu, M. Jaderberg, W. M. Czarnecki, A. Dudzik, A. Huang, P. Georgiev, R. Powell *et al.*, "Alphastar: Mastering the real-time strategy game starcraft ii," *DeepMind blog*, p. 2, 2019.

[8] S. Corbett-Davies, E. Pierson, A. Feller, S. Goel, and A. Huq, "Algorithmic decision making and the cost of fairness," in *Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2017, pp. 797–806.

[9] J. Baldwin-Philippi, "The myths of data-driven campaigning," *Political Communication*, vol. 34, no. 4, pp. 627–633, 2017.

[10] S. Russell and P. Norvig, *Artificial intelligence: a modern approach*. Prentice Hall, 2002.

[11] S. Legg and M. Hutter, "A collection of definitions of intelligence," *Frontiers in Artificial Intelligence and applications*, vol. 157, p. 17, 2007.

[12] R. J. Sternberg, "The concept of intelligence and its role in lifelong learning and success." *American psychologist*, vol. 52, no. 10, p. 1030, 1997.

[13] A. Nareyek, "Ai in computer games," *Queue*, vol. 1, no. 10, pp. 58–65, 2004.

[14] S. Legg and M. Hutter, "Universal intelligence: A definition of machine intelligence," *Minds and machines*, vol. 17, no. 4, pp. 391–444, 2007.

[15] N. B. Adams, "Digital intelligence fostered by technology." *Journal of Technology Studies*, vol. 30, no. 2, pp. 93–97, 2004.

[16] E. Alpaydin, *Introduction to machine learning*. MIT press, 2020.

[17] I. Goodfellow, Y. Bengio, and A. Courville, *Deep learning*. MIT press, 2016.

[18] J. Liu, Y. Xiao, and J. Wu, "From ai to ci: A definition of cooperative intelligence in autonomous driving," in *International Conference on Internet of Vehicles*. Springer, 2019, pp. 64–75.

[19] P. Krafft, M. Young, M. Katell, K. Huang, and G. Bugingo, "Defining ai in policy versus practice," in *Proceedings of the AAAI/ACM Conference on AI, Ethics, and Society*, 2020, pp. 72–78.

[20] O. Kanevskaia, "The need for multi-disciplinary education about standardization," in *Sustainable Development*. Springer, 2020, pp. 161–178.

[21] E. Eaton, S. Koenig, C. Schulz, F. Maurelli, J. Lee, J. Eckroth, M. Crowley, R. G. Freedman, R. E. Cardona-Rivera, T. Machado *et al.*, "Blue sky ideas in artificial intelligence education from the eaai 2017 new and future ai educator program," *AI Matters*, vol. 3, no. 4, pp. 23–31, 2018.

[22] N. Garrett, N. Beard, and C. Fiesler, "More than" if time allows" the role of ethics in ai education," in *Proceedings of the AAAI/ACM Conference on AI, Ethics, and Society*, 2020, pp. 272–278.

[23] M. Wollowski, R. Selkowitz, L. E. Brown, A. Goel, G. Luger, J. Marshall, A. Neel, T. Neller, and P. Norvig, "A survey of current practice and teaching of ai," in *Thirtieth AAAI Conference on Artificial Intelligence*, 2016.

[24] M. Daily, S. Medasani, R. Behringer, and M. Trivedi, "Self-driving cars," *Computer*, vol. 50, no. 12, pp. 18–23, 2017.

[25] A. Aslam, E. Khan, and M. Beg, "Improved edge detection algorithm for brain tumor segmentation," *Procedia Computer Science*, 2015.

[26] G. Mazzini, "A system of governance for artificial intelligence through the lens of emerging intersections between ai and eu law," *Digital Revolution–New challenges for Law*, 2019.

[27] S. Park *et al.*, "The role of government in science and technology legislation to prepare for the era of artificial intelligence," in *Proceedings of Law and Political Sciences Conferences*, no. 7909652. International Institute of Social and Economic Sciences, 2018.

[28] N. Akhtar and A. Mian, "Threat of adversarial attacks on deep learning in computer vision: A survey," *IEEE Access*, vol. 6, pp. 14 410–14 430, 2018.

[29] F. Lagioia and G. Sartor, "Ai systems under criminal law: a legal analysis and a regulatory perspective," *Philosophy & Technology*, pp. 1–33, 2019.

[30] H. Zhou, H. Zhang, Y. Zhou, X. Wang, and W. Li, "Botzone: an online multi-agent competitive platform for ai education," in *Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education*, 2018, pp. 33–38.

[31] D. A. Kolb, R. E. Boyatzis, C. Mainemelis *et al.*, "Experiential learning theory: Previous research and new directions," *Perspectives on thinking, learning, and cognitive styles*, vol. 1, no. 8, pp. 227–247, 2001.

[32] E. Eaton, "Teaching integrated ai through interdisciplinary project-driven courses," *AI Magazine*, vol. 38, no. 2, pp. 13–21, 2017.

[33] E. Burton, J. Goldsmith, and N. Mattei, "Teaching ai ethics using science fiction," in *Workshops at the Twenty-Ninth AAAI Conference on Artificial Intelligence*, 2015.

[34] S. H. Broughton, G. M. Sinatra, and E. M. Nussbaum, "“pluto has been a planet my whole life!” emotions, attitudes, and conceptual change in elementary students' learning about pluto's reclassification," *Research in Science Education*, vol. 43, no. 2, pp. 529–550, 2013.

[35] R. Duit and D. F. Treagust, "Conceptual change: A powerful framework for improving science teaching and learning," *International journal of science education*, vol. 25, no. 6, pp. 671–688, 2003.

[36] S. Vosniadou, "Initial and scientific understandings and the problem of conceptual change," in *Converging Perspectives on Conceptual Change*. Routledge, 2017, pp. 17–25.

[37] J. D. Bransford, A. L. Brown, R. R. Cocking *et al.*, *How people learn*. Washington, DC: National academy press, 2000, vol. 11.

[38] F. Dochy, "Instructional implications of recent research and empirically-based theories on the effect of prior knowledge on learning," in *Learning Environments*. Springer, 1990, pp. 339–355.

[39] B. A. Simonsmeier, M. Flaig, A. Deiglmayr, L. Schalk, and M. Schneider, "Domain-specific prior knowledge and learning: a meta-analysis," *Research Synthesis 2018, Trier, Germany*, 2018.

[40] C. S. Sunal, C. L. Karr, and D. W. Sunal, "Fuzzy logic, neural networks, genetic algorithms: Views of three artificial intelligence concepts used in modeling scientific systems," *School Science and Mathematics*, vol. 103, no. 2, pp. 81–91, 2003.

[41] I. Tussyadiah and G. Miller, "Perceived impacts of artificial intelligence and responses to positive behaviour change intervention," in *Information and Communication Technologies in Tourism 2019*. Springer, 2019, pp. 359–370.

[42] E. Fast and E. Horvitz, "Long-term trends in the public perception of artificial intelligence," in *Thirty-First AAAI Conference on Artificial Intelligence*, 2017.

[43] D. P. Dos Santos, D. Giese, S. Brodehl, S. Chon, W. Staab, R. Kleinert, D. Maintz, and B. Baeßler, "Medical students' attitude towards artificial intelligence: a multicentre survey," *European radiology*, vol. 29, no. 4, pp. 1640–1646, 2019.

[44] A. Strauss and J. Corbin, "Open coding," *Basics of qualitative research: Grounded theory procedures and techniques*, vol. 2, no. 1990, pp. 101–121, 1990.

[45] L. Czerniewicz, A. Deacon, M. Glover, and S. Walji, "Mooc—making and open educational practices," *Journal of Computing in Higher Education*, vol. 29, no. 1, pp. 81–97, 2017.

[46] T. Dillahunt, Z. Wang, and S. D. Teasley, "Democratizing higher education: Exploring mooc use among those who cannot afford a formal education," *International Review of Research in Open and Distributed Learning*, vol. 15, no. 5, pp. 177–196, 2014.

[47] S. Laato, H. Salmento, N. Heinonen, E. Lipponen, H. Vilppu, H. Virtanen, and M. Murtonen, "Solving diversity issues in university staff training with unips pedagogical online courses," in *2019 IEEE Learning With MOOCS (LWMOOCS)*. IEEE, 2019, pp. 138–144.

[48] N. Sonwalkar, "The first adaptive mooc: A case study on pedagogy framework and scalable cloud architecture—part i," in *MOOCs Forum*, vol. 1. Mary Ann Liebert, Inc. 140 Huguenot Street, 3rd Floor New Rochelle, NY 10801 USA, 2013, pp. 22–29.

[49] A. Fitzgerad, J. König, and I. H. Witten, "F-lingo: Integrating lexical feature identification into mooc platforms for learning professional and academic english," in *2019 IEEE Learning With MOOCS (LWMOOCS)*, Oct 2019, pp. 101–104.

[50] S. Laato, E. Lipponen, H. Salmento, H. Vilppu, and M. Murtonen, "Minimizing the number of dropouts in university pedagogy online courses," in *CSEDU 2019-Proceedings of the 11th International Conference on Computer Supported Education*, vol. 1, 2019, pp. 587–596.

[51] S. Laato, A. N. Islam, M. N. Islam, and E. Whelan, "What drives unverified information sharing and cyberchondria during the covid-19 pandemic?" *European Journal of Information Systems*, pp. 1–18, 2020.

[52] A. R. Hevner, S. T. March, J. Park, and S. Ram, "Design science in information systems research," *MIS quarterly*, pp. 75–105, 2004.