AI AND EDUCATION ON CLIMATE CHANGE MITIGATION – FROM KING MIDAS PROBLEM TO A GOLDEN OPPORTUNITY?

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Sustainable Development Goal 13 - Climate Action

Target within SDG Goal: 13.3 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

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1. Purpose and context of the research

After the adoption of the 2030 Agenda for Sustainable Development[1] by the Member States of the United Nations, the 17 Sustainable Development Goals (SDGs), broken down into 169 targets, have become a "shared blueprint for peace and prosperity for people and the planet".[2] While some in the scientific community have expressed certain criticism regarding the way SDGs are formulated – estimating that they are "inconsistent, difficult to quantify, implement and monitor" (Swain 2018, p. 341), but also criticizing them "for reproducing a universal template grounded in a western and neoliberal ideology" (Arora-Jonsson 2023, p. 2) – it is difficult to deny that the SDGs represent a good global and universally known common ground, both for governmental and civil society activities, as well as for further reflection within the widest expert and scientific fora.

The moto of the SDG 13 (Climate Action) is "take urgent action to combat climate change and its impacts". No one serious denies the more and more harmful consequences of climate change all over the globe, with "climate records […] shattered in 2023 [and] the communities around the world suffering the effects of extreme weather, which is destroying lives and livelihoods on a daily basis".[3] As one of three targets within SDG 13, Target 13.3 (Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning) tackles one of the crucial issues of climate action – the need to adapt the way we learn, teach and inform about climate change mitigation. Unfortunately, the results achieved in this field are very modest. According to the latest Progress Report of the UN Secretary-General ("Progress towards the SDGs"), "a study in 2023 of more than 530 grade 9 science and social science subject curricula found that 69% contained no reference to climate

> *"A STUDY IN 2023 OF MORE THAN 530 GRADE 9 SCIENCE AND SOCIAL SCIENCE SUBJECT CURRICULA FOUND THAT 69% CONTAINED NO REFERENCE TO CLIMATE CHANGE AND 66% MADE NO MENTION OF SUSTAINABILITY" … "THREE-QUARTERS OF COUNTRIES REPORTED THEY HAVE PLANS TO REVISE THEIR CURRICULA IN THE NEXT THREE YEARS TO FOCUS MORE ON CLIMATE CHANGE AND SUSTAINABILITY".*
>
> *(UN SECRETARY-GENERAL, PROGRESS TOWARDS THE SUSTAINABLE DEVELOPMENT GOALS, MAY 2024)*

[1] Detailed description of the SDGs and their content: <https://sdgs.un.org/goals>, accessed on 10 August 2024.
[2] *Ibid.*
[3] Progress Report of the UN Secretary-General, May 2024, p. 19, <https://unstats.un.org/sdgs/files/report/2024/SG-SDG-Progress-Report-2024-advanced-unedited-version.pdf>, accessed on 13 August 2024.

change and 66% made no mention of sustainability".[4] These regrettable findings are, to a certain extent, toned down by adding that "three-quarters of countries reported they have plans to revise their curricula in the next three years to focus more on climate change and sustainability".[5] There is, however, no mention on how those "three-quarters of countries" consider to revise the curricula, on which levels, in the context of which subject matters and, above all, using what kind of educational methods and techniques. It is, however, important to note that the process of curricular reforms in this direction was timidly initiated in some countries. For example, in a report published on 4 September 2024, Oxford, Cambridge and RSA Examinations (OCR) called for the creation of an independent body to maintain a "far more contemporary and forward-looking" curriculum, more focused on climate change and sustainability, but also insisting on the need for education about the appropriate use of artificial intelligence.[6]

Artificial intelligence (AI) has an undisputed aptitude to serve as a tool in improving education, learning and teaching methods (AIED). The objective of this paper is to evaluate the specific impact of AI on SDG target 13.3, with a focus on education on climate change mitigation. To do so, the author used two main methods. On the one hand, the research was be based on critical examination of the existing scientific studies dedicated to AIED, with a special focus on their applicability in various educational programs and methods dedicated to climate change mitigation; the main results of this aspect of research are presented in Chapter 3 of this paper (State of the research on AIED and its applicability in education on climate change mitigation – a critical overview). On the other hand, the evaluation of the future potential impact of AIED on education on climate change mitigation was both qualitative and quantitative. It was based on two adapted questionnaires (Q1 and Q2, more details below) and on a specific tool to process the gathered data; the main results of this aspect of research are presented in Chapters 5 (Results of the surveys) and 6 (Projection and conclusions) of this paper. Finally, special attention was paid to the analysis of the most recent supra-national regulatory effort (European Union's Regulation of 13 June 2024 laying down harmonized rules on artificial intelligence – EU AI Act) to regulate AI and its potential impact on education and, more specifically, on education on climate change mitigation (Chapter 4).

[4] *Ibid*, p. 20.
[5] *Ibid.*
[6] OCR – Striking the balance <https://teach.ocr.org.uk/striking-the-balance>, accessed on 4 September 2024; "England's school curriculum needs reform to fix 'glaring omissions', review finds", Financial Times https://www.ft.com/content/7b0fe220-32ed-43b3-8178-01751aa5730fp, accessed on 4 September 2024.

2. Methodological approach

While plethora of studies have already assessed the possible advantages and shortcomings of AI as a tool in improving education,[7] learning and teaching methods (AIED), those exclusively dedicated to the impact of AIED on climate change mitigation are practically non-existent. However, many of them include a number of findings relevant for the proposed research.

THE RESEARCH OPERATES WITH TWO BIG SOURCES OF DATA. THIS CHOICE IS IMPOSED BY THE COMPLEXITY OF POSSIBLE INTERACTIONS BETWEEN AIED SYSTEMS AND HUMAN DECISION-MAKERS, AS WELL BY THE NATURE OF INTERPLAY BETWEEN AUTOMATED AND HUMAN DECISION-MAKING.

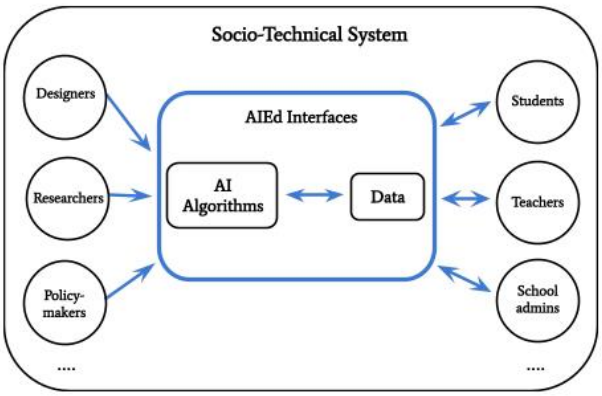
The evaluation of the impact of AIED in education for climate change mitigation was qualitative and quantitative. It was based on two adapted questionnaires (Q1 and Q2, more details about the results of the survey in Chapter 5; questionnaires are annexed to this paper) and on a specific tool to process the gathered data.

Some of the key criteria to determine and measure the impact of AIED on the achievement of SDG target 13.3 were: 1) level of inclusion of AI-based educational tools in the existing higher education curricula; 2) level of interoperability of the above tools in natural and social sciences and 3) feedback given by educators in their answers to Q2. The results obtained through the surveys were scrutinized and quantified.

The research operates with two big sources of data. This choice is imposed by the complexity of possible interactions between AIED systems and human decision-makers (Hostein&Doroudi, 2022), as well by the nature of interplay between automated and human decision-making (Yuan et all, 2023; see graph 2 below).

[7] See Chapter 1 of this paper.

Lens 4 (Human–Algorithm): Interplay between Automated and Human Decision-making



Graph 1. *Source: Yuan et all, Springer, 2023*

The first bundle of data (see Chapter 3) was collated through the critical examination of numerous existing studies that have already assessed the possible advantages and shortcomings of AIED; gathered data is then scrutinized, in order to distil whether or not (and, if yes, to what extent) AIED impacted and could impact the realization of SDG target 13.3. In order to complete the above-mentioned scientific insights with an analysis of current legislation, special attention was paid to the analysis of the most recent supra-national regulatory effort (*European Union's Regulation of 13 June 2024 laying down harmonised rules on artificial intelligence* – EU AI Act, see Chapter 4) to regulate AI and its potential impact on education and, more specifically, on education on climate change mitigation.

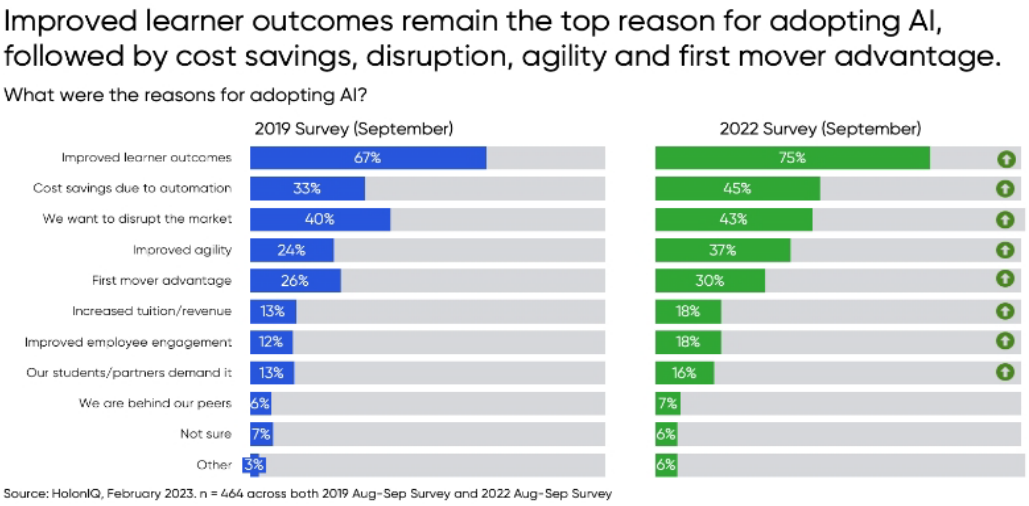
The second valuable source of data (see Chapter 5) was gathered through two different, tailor-made questionnaires (Q1 and Q2). Q1, addressed to the researchers who have already achieved significant results in the field of AI studies, was designed in order to try and distil the climate change related aspects of the existing studies of AIED. Q2 was sent to the representatives of 52 selected educational and research institutions worldwide and is focused on the recent and most relevant impacts of AI in education and awareness raising on climate change mitigation.

The analysis of the potential future impact of AI on the achievement of SDG target 13.3 was directly correlated with the following main evaluation criteria:

1) level of inclusion of AI-based educational tools in the existing higher education curricula, and
2) level of interoperability of the above tools in natural and social sciences and feedback given by educators in their answers to Q2.

3. State of the research on AIED and its applicability in education on climate change mitigation – a critical overview

Until now (early September 2024), in terms of ethical and other value-related considerations, the less dubitative track record AI has had is the one related to its aptitude to serve as a tool in improving education, learning and teaching methods (AIED). As numerous researches have shown, "all empirical studies […] presented the positive effects of AI techniques on education" (Zhai et all, 2021), while in educational applications, the combination of knowledge-based and data-driven approaches represents a natural path forward (Holmes & Tuomi, 2022). However, while improved learner outcomes remain the top reason for adopting AI (see Graph 2 below), some point to the dangers of AIED colonialism and asymmetries in power across and between nations (Holmes, 2020).



Graph 2. Source: HolonIQ, https://www.holoniq.com/notes/2023-global-education-outlook

The most substantial criticism related to the place of AI in educational ecosystem is the one that focuses on the major economic and, to a lesser extent, political drivers that have led to its introduction. In such a context, when practically all AI tools are developed and/or provided by profitable entities – whose unique or predominant objective is to commercialize their services in a way that maximizes economic gain – the needs of learner can easily be overrun by other considerations based on productivity, rapidity and gain. As it was rightfully pointed out, "pursuit of marketable products […] appears to define the general approach of the private sector, rather than any underlying educational rationale for the design and development of AI applications" (Knox 2020, p. 16). In such a context, tailor-made approach to education, based on learner's individual pedagogical needs, has all the chances to be neglected. Therefore, improved learner outcomes mentioned in the previous paragraph can be seen under a different light, allowing to further question the ways they were measured, especially if one takes in consideration that "cost savings due to automation" (see Graph 2) can significantly compromise the individual approach in learning. Finally, a detailed analysis, elaborated in 2022 under the auspices of the Council of Europe by a group of five authors (Wayne Holmes, Jen Persson, Irene-Angelica Chounta, Barbara Wasson and Vania Dimitrova)[8] defined some major threats AIED could represent for human rights, democracy, and rule of law. Although this document is, most often, limited to the description of normative standards, it also includes a good review of the existent studies dedicated to AIED; however, it openly admits that "there is little substantive literature that focuses specifically on, or even mentions in any meaningful way, AI, education and human rights".[9]

THE MOST SUBSTANTIAL CRITICISM RELATED TO THE PLACE OF AI IN EDUCATIONAL ECOSYSTEM IS THE ONE THAT FOCUSES ON THE MAJOR ECONOMIC AND, TO A LESSER EXTENT, POLITICAL DRIVERS THAT HAVE LED TO ITS INTRODUCTION. IN SUCH A CONTEXT, WHEN PRACTICALLY ALL AI TOOLS ARE DEVELOPED AND/OR PROVIDED BY PROFITABLE ENTITIES – WHOSE UNIQUE OR PREDOMINANT OBJECTIVE IS TO COMMERCIALIZE THEIR SERVICES IN A WAY THAT MAXIMIZES ECONOMIC GAIN – THE NEEDS OF LEARNER CAN EASILY BE OVERRUN BY OTHER CONSIDERATIONS BASED ON PRODUCTIVITY, RAPIDITY AND GAIN.

[8] "Artificial intelligence and education - a critical view through the lens of human rights, democracy and the rule of law", Council of Europe – Provisional edition, <https://www.developmentaid.org/api/frontend/cms/file/2022/11/Artificial-Intelligence-and-education_eng.pdf>, accessed on 31 August 2024.
[9] *Ibid*, p. 51.

Education on climate change mitigation (ECCM) is a complex issue and has numerous specificities, out of which the most important are its cross-disciplinary nature, high global socio-economic stakes and exigency to reach educational goals. First, cross-disciplinarity, in principle, requires rapid analytical tools, capable of processing large amount of data in a short time. Second, high global socio-economic stakes impose the need for effective, universally applicable and decomplexified educational tools, also capable of combating multifaceted prejudices, misbelieves and conspiracy theories about (non)existence of climate change, that are constantly popping-up in numerous countries of the world, especially in times of elections or other moments when important societal choices are made. Third, exigency to reach educational goals demands adaptable and universal curricula, designed in a way that can easily be integrated in various existing educational modules in elementary and high schools, regardless the outdated and conservative classifications, such as the most classical one (formal, natural and social sciences). All the above-mentioned specificities taken into consideration, it can be concluded that AI based educational tools in education on climate change mitigation can be, in numerous aspects, more adapted to specific pedagogical goals and learner's needs than AI educational tools in general. Moreover, even some pertinent critical remarks regarding the impact of AI based learning on human rights, democracy and rule of law are not applicable (or applicable to a much lesser extent) to AI-assisted education on climate change mitigation.

EDUCATION ON CLIMATE CHANGE MITIGATION (ECCM) IS A COMPLEX ISSUE AND HAS NUMEROUS SPECIFICITIES, OUT OF WHICH THE MOST IMPORTANT ARE ITS CROSS-DISCIPLINARY NATURE, HIGH GLOBAL SOCIO-ECONOMIC STAKES AND EXIGENCY TO REACH EDUCATIONAL GOALS.

4. European Union's AI Act and its potential impact on education and ECCM

4.1. Regulation of AI as a global challenge

The regulation of AI – especially if we focus on legally binding acts – is critically lagging behind a conspicuous enthusiasm for the debate on AI-related issues. While there is a proliferating number of various ethic guidelines and rules of conduct – prepared and published by plethora of different entities and organisms in order to limit the use of unwanted and potentially harmful AI practices and to contribute to what is often referred to as "responsible AI" (Voeneky et all. 2022) – the legal acts belonging to so called "hard law" on AI are significantly less numerous.

There is, however, a clear tendency to regulate AI in growing number of national legislations all over the globe. In January 2024, the International Association of Privacy Professionals published a document entitled "Global AI Law and Policy Tracker",[10] examining "the development of comprehensive legislation, focused legislation for specific use cases, national AI strategies or policies, and voluntary guidelines and standards"[11] in 23 countries, but also in the EU. In overwhelming majority of analysed countries, national "laws and policies" applicable to some aspects of AI are predominantly covering issues such as personal data protection, consumer protection, digital economy and various questions related to intellectual property rights (IPR), but rarely comprise legally binding regulation dedicated exclusively to AI. In any case, the EU Regulation of 13 June 2024 laying down harmonized rules on artificial intelligence[12] (hereinafter referred to as the AI Act – AIA) is the first supranational legally binding act of this kind.

4.2. European Union's AI Act

The *Proposal for a regulation of the European Parliament and of the Council on laying down harmonised rules on Artificial Intelligence* (AIA), published by the European Commission in April 2021, was the first formal step leading to the adoption of Union's regulatory framework exclusively

[10] <https://iapp.org/media/pdf/resource_center/global_ai_law_policy_tracker.pdf>, accessed on 20 August 2024.
[11] *Ibid*, p. 2.
[12] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act), OJ L series, 12.7.2024.

dedicated to AI. This text was the fruit of long and laborious discussions, during which one the two important milestones were the Commission's communication entitled "Artificial Intelligence for Europe"[13] (April 2018) and its Report on the safety and liability implications of Artificial Intelligence, the Internet of Things and robotics[14] (February 2020). On 13 March 2024, almost three years after its initial publication, the European Parliament (EP) – in the first reading and according to ordinary legislative procedure – officially adopted the proposal of the AIA. Two months later, on 21 May 2024, the Council of the EU approved the text[15] and it was published in the EU's Official Journal on 12 July 2024.

By the simple fact that it represents the first supranational legal effort to comprehensively regulate AI, the AIA "must be welcomed, especially as it provides a basis for an urgently needed constructive dialogue on a matter of extreme and ubiquitous importance" (Neuwirth 2023, p. 13). In the same vein, legislator's laudable effort to justify document's background and various regulatory solutions – the AIA has 180 recitals – speaks strongly in favour of the open, inclusive and democratic process in which it has been elaborated. However, the particularities of the decision-making process within the EU and its intrinsic slowness have led to a belated adoption of an act which – striving to satisfy numerous and often contradictory economic, political and other (Nikolinakos 2023) interests – did not go far enough, potentially leading either to its limited effects or to significant problems in its future enforcement in the EU Member States. Through a critical examination of the provisions of AIA dedicated to the prohibited AI practices, the objective of this chapter is to try and distil if and to what extent the AIA will serve the purpose it is adopted for – to promote "the uptake of human centric and trustworthy artificial intelligence"[16] in the field of education. After a brief overview of AI practices prohibited by Art. 5-1 of the AIA (sub-chapter 4.2.1), The focus will be on two (out of eight) prohibited AI practices that are of particular importance for education in general, as well as for ECCM (sub-chapters 4.2.2. and 4.2.3.). It will be questioned how and to what extent the numerous legal standards related to the definition of these practices can lead to uncertainties regarding their interpretation.

4.2.1. An overview of AI practices prohibited by Art. 5-1 of the AIA

Article 5.1 of the AIA is exclusively dedicated to the enumeration of prohibited AI practices, bringing an exhaustive list of those practices, therefore not allowing the potential prohibition of any future potential use of AI that is not provided for in points 5.1(a) to 5.1(h).[17] This nomotechnical

[13] COM(2018) 237 final <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A237%3AFIN>, accessed on 21 August 2024.
[14] COM(2020) 64 final, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0064>, accessed on 21 August 2024.
[15] The working version of text approved by the EU Council <https://data.consilium.europa.eu/doc/document/PE-24-2024-INIT/en/pdf>, accessed on 22 August 2024.
[16] Recital 1 of the AIA.
[17] Apart from prohibited AI practices examined in sub-chapters 4.2.2. and 4.2.3. of this paper, other six practices

choice can be understood from the point of view of general considerations related to the rule of law and legal certainty. However, extremely rapid development of AI and of various ways of its misuse would soon require the adoption of more and more substantial amendments to the AIA. Taking into consideration both complexity and slowness of the EU's legislative procedures – issues which have been summarily examined in the last chapter – it is very likely that the existing provisions of the AIA will soon be (at least partially) insufficient, inadequate or inapplicable. Nevertheless, in the current state of the development of AI, the AIA offers more or less adequate answers to the main concerns, especially when AI is misused to "provide novel and powerful tools for manipulative, exploitative and social control practices" (recital 28 of the AIA). In any case, seven of eight points of Art. 5.1 prohibit "the placing on the market, the putting into service or the use" of various AI system(s) (points a-f) or biometric categorization systems (point g) or "'real-time' remote biometric identification systems" (point h).

4.2.2. Subliminal, manipulative or deceptive techniques

Linguistic, contextual and teleological interpretation of the provision of Art. 5.1(a) indicates that it is a complex legal norm, comprised of five mandatory cumulative constitutive elements. In other words, an AI-related practice cannot be deemed to be prohibited under EU law if it does not fulfil all the conditions, out of which four are specific only for this particular kind of practice, while the fifth represents a common characteristic of all cases listed in points (a) to (g). Therefore, here the focus will be on the four specific conditions characterizing only the practice which summarily can be referred to as the one leading to the distortion of behaviour. Some of these practices can easily be integrated in various media and educational contents and, therefore, used for deceptive and manipulative purposes, potentially leading to significant changes in person's behaviour, such as, for example, reduction of value-oriented environmental activism.

regulated by Art. 5.1. of the AIA are: 1) evaluation or classification of persons or groups of persons; 2) risk assessment through human profiling; 3) facial recognition databases; 4) inferring of human emotions; 5) biometric categorisation of humans; and 6) real-time remote biometric identification systems.

WHAT CAN BE CONSIDERED AS A LEGITIMATE CHANGE IN A PERSON'S DECISION-MAKING ROUTINES SO THAT IT CAN BE CERTIFIED AS AUTHENTIC, GENUINE, AND NOT INFLUENCED BY "AN AI SYSTEM THAT DEPLOYS SUBLIMINAL TECHNIQUES"? IN OTHER WORDS, HOW TO MAKE SURE THAT THIS PARTICULAR PERSON "WOULD NOT HAVE OTHERWISE TAKEN" A DIFFERENT DECISION EVEN IN A TOTAL ABSENCE OF WHICHEVER AI SYSTEM DEPLOYING "SUBLIMINAL, PURPOSEFULLY MANIPULATIVE OR DECEPTIVE TECHNIQUES"? IS THIS PROVISION OF NEWLY ADOPTED EU ACT INDIRECTLY IMPLYING THAT THE HUMAN BEHAVIOR IS USUALLY ALMOST ENTIRELY PREDICTABLE, AND THAT "AN INFORMED DECISION" – AT LEAST IN A UNIVERSE LIMITED TO PERSON'S INDIVIDUAL COGNITIVE ABILITIES AND ETHICAL PREFERENCES – IS A MATHEMATICALLY PRECISE VALUE, THE DISTURBANCE OF WHICH CAN BE EASILY OBSERVED, THUS ENTIRELY REDUCING THE POSSIBILITY OF WHICHEVER "UNWANTED" DECISION?

4.2.2.1. First, an AI system has to deploy at least one of the following three techniques: 1) subliminal technique beyond a person's consciousness; 2) purposefully manipulative or 3) deceptive techniques.

4.2.2.2. Second, the deployment of such a technique(s) has to be characterized by a specific objective or effect, which, in itself, has two elements; the first element has to be objectively manifested in reality and consists of a material distortion in the behaviour of "a person or a group of persons"; on the other hand, the second element is situated entirely (and, consequently, can be observed exclusively) on the level of individual consciousness of "manipulated" natural person, because the above mentioned distortion has to be caused by an **appreciable impairment** of person's ability to make an informed decision. This impairment can be seen as a subjective element, intrinsically correlated with the objective one. Moreover, the level of the impairment referred to as "appreciable" can only be judged from the point of view of the latter.

4.2.2.3. Third, the distortion in the behaviour of "a person or a group of persons", even if it is confirmed – potentially using techniques which are far beyond purely legal considerations and can vaguely be situated somewhere between psychoanalysis and forensic psychology – that the distortion was appreciable, is not sufficient to establish the existence of a prohibited AI practice. It is also necessary to have an objective manifestation of this distortion in the behaviour: the fact that this particular person has taken "a decision that that person would not have otherwise taken". This element is probably the weakest point of the entire construction of this particular type of prohibited AI practice. Even if we imagine a situation in which it is established that, first, a technique used had the objective/effect of **materially distorting a behaviour** and, second, the person's ability to make an informed decision was appreciably impaired, how to make sure that the fact this particular person has taken a different decision than the one he/she usually takes is a direct consequence of an AI practice? What can be considered as a legitimate change in a person's decision-making routines so that it can be certified as authentic, genuine, and not influenced by "an AI system that deploys subliminal techniques"? In other words, how to make sure that this particular person "would not have

otherwise taken" a different decision even in a total absence of whichever AI system deploying "subliminal, purposefully manipulative or deceptive techniques"? Is this provision of newly adopted EU act indirectly implying that the human behaviour is usually almost entirely predictable, and that "an informed decision" – at least in a universe limited to person's individual cognitive abilities and ethical preferences – is a mathematically precise value, the disturbance of which can be easily observed, thus entirely reducing the possibility of whichever "unwanted" decision? To put it bluntly, whose intelligence is really artificial here? All these questions tackle at least two very sensitive and mainly meta-legal issues. The first is widely discussed in philosophy and concerns complex relations between the human perception and free will,[18] while the second concerns the importance of both the liberty of consciousness and the freedom of opinion not only for the values of human rights and democracy, but also for the concept of a society that gave birth to them.

4.2.2.4. Fourth, the "unwanted" decision the previous paragraph referred to has to cause or to be likely to cause a significant harm to a broadly defined list of entities (the person who made the decision, but also another person or group of persons). While, by its apparent objectivity, this element of the provision does not seem to be potentially leading to the problems of interpretation, it, however, raises at least two other important questions. First, in order for an AI practice to be prohibited under the provision of Art. 5.1(a), a harm has to be a direct effect of a distorted behaviour that have led to an unwanted decision; in other words, the link cause to effect has to be established between, on the one hand, the decision of a person/group of persons (taken under the influence of an AI system) and, on the other, the harm caused. Second, this harm has to be significant, which is yet another standard potentially leading to diverging interpretations.

4.2.3. Exploitation of vulnerability

As it was the case with the techniques leading to the distortion of behaviour, this type of prohibited AI practice is comprised of several mandatory cumulative constitutive elements, out of which one is exactly the same (material distortion of the behaviour), but devoid of the component related to appreciable impairment of person's ability to make an informed decision. The second common element of the two types of prohibited AI practices is a significant harm caused, but, however, with some terminological and substantial specificities compared to the practice defined in Art. 5-1(a). It is, therefore, necessary to examine in detail all the constitutive elements of this prohibited AI practice.

[18] For an overview of several possible approaches to the topic, see Uri Maoz, Walter Sinnott-Armstrong (eds.), Free Will: Philosophers and Neuroscientists in Conversation, Oxford, OUP 2022; Alfred Mele (ed.), Surrounding Free Will: Philosophy, Psychology, Neuroscience, Oxford, OUP 2015.

4.2.3.1. First, an AI system has to exploit "any of the vulnerabilities of a person or a specific group of persons," but only if they are due to person's/group's "age, disability or a specific social or economic situation". It should be noted that there is a number of concrete situations in which a person/group can find itself that could only be encompassed by the notion of "specific social situation" if it is interpreted *lato sensu*. For example, can the citizenship, ethnic or racial belonging, mother tongue and other languages spoken be considered as a specific social situation? In spite of a tendency in sociology and political science to establish a connection between citizenship and social class (Marshall 1950), the recent studies are more inclined to deeply question this connection, claiming that the crisis of welfare state is accompanied with "the tensions of present-day unsustainable society where social inequalities are growing dramatically (Benassi & Mingione 2024, p. 53)." Moreover, the stable interpretation of the Court of Justice of the EU undoubtedly goes in direction of the neat decoupling of the notions of citizenship (*nationalité*) and social situation,[19] arguing in favour of an interpretation that "social status" indicates all other material conditions of life that are not necessarily related to income. Therefore, it is difficult to imagine that the EU legislation on prohibited AI practices will be applicable if a person's/group's vulnerability is due to their citizenship, ethnicity or language(s) they (do not) speak, even if it is technically possible to design an AI system exploiting the vulnerabilities based on the above-mentioned criteria.

IN ORDER FOR AN AI PRACTICE TO BE PROHIBITED UNDER EU LAW, THE DISTORTION OF THE BEHAVIOR CAN ONLY CONCERN A NATURAL PERSON, INDEPENDENTLY OF THE FACT WHETHER IT EXPLOITS HER/HIS INDIVIDUAL OF COLLECTIVE VULNERABILITY. IN OTHER WORDS, VULNERABILITY AS SUCH CAN EXIST IN FORO EXTERNO, BUT ONLY IF IT AFFECTS INDIVIDUAL BEHAVIOR. THIS IS OF PARTICULAR IMPORTANCE IN EDUCATIONAL MATTERS, WHEN LEARNER'S BELONGING TO A GROUP CAN BE USED TO INFER INDIVIDUAL VALUE-ORIENTED CHOICES, AS WELL AS TO DISSEMINATE MISINFORMATION AND CONSPIRACY THEORIES RELATED TO CLIMATE CHANGE.

4.2.3.2. Second, the exploitation of a vulnerability analysed in the previous paragraph has to have as the objective or the effect to materially distort the behaviour of a person. At a first glance, this condition can seem to be identical to the first of two elements analysed in the paragraph 4.2.2.2., in the context of subliminal and other techniques leading to the distortion of behaviour. However, unlike for the latter, the distortion of the behaviour cannot affect "a person or a group of persons" but "that person or a person belonging to that group". Consequently, the

[19] Whenever the Court of Justice of the EU or its Court of First Instance (CFI) refer to "social situation" of a natural person, they examine it in the light of broader context of person's material conditions of living (see cases *Bärbel Kachelmann* - C-322/98 and Saxonia *Edelmetalle GmbH v Commission of the European Communities* - joined cases T-111/01 and T-113/01).

vulnerability referred to in paragraph 4.2.3.1. can be either individual or collective, but in order for an AI practice to be prohibited under EU law, the distortion of the behaviour can only concern a natural person, independently of the fact whether it exploits her/his individual of collective vulnerability. In other words, vulnerability as such can exist *in foro externo*, but only if it affects individual behaviour. This is of particular importance in educational matters, when learner's belonging to a group can be used to infer individual value-oriented choices, as well as to disseminate misinformation and conspiracy theories related to climate change.

4.2.3.3. Finally, third, the material distortion of the behaviour has to be followed by a "significant harm", yet another element comparable to the one already examined in paragraph 4.2.2.4. However, there are two important specificities. First, by analogy with what has already been concluded in the previous paragraph, the harm can only be individual and not inflicted on the group. Second, unlike for subliminal, manipulative or deceptive techniques, it is not necessary that the significant harm has actually taken place, but it is sufficient that this harm is "reasonably likely" to happen. Even if both the literature and the case-law are abundant when it comes to the interpretation of this *terminus technicus*, it is not yet known how the Court of Justice of the EU will interpret what is a reasonable risk of harm in the context of prohibited AI practices.

5. Results of the surveys

The surveys were carried out on the basis of two separate – but intrinsically interconnected are complementary – questionnaires (Q1 and Q2, attached in annex to this document). In Q2, the responses were meant to be anonymous, so that it expresses neither any kind of institutional position or standpoint, nor it was asked to reveal the identity of person responding to the questions.

Q1 was addressed to 14 researchers who have already achieved (and published) significant results in the field, and was designed in order to try and distil the climate change related aspects of the existing studies of AIED (see also Chapter 3 of this document). The responsiveness of the surveyed researchers can be assessed as satisfactory, given that, out of 14 questionnaires (sent from 19 July until 3 August 2024) until 9 September 2024, 12 of them sent their responses with filled-in questionnaires – **85.7% of total number of Q1 sent**. One of the main reasons for such responsiveness was, most probably, the personal involvement of the researchers and their wish to engage in scientific study and debate, as well as to disseminate the results of their research.

Q2 was sent to 52 selected educational institutions worldwide and was focused on the recent and most relevant impacts of AI in education and awareness raising on climate change mitigation. In order to ensure higher responsiveness, Q2 were, most often, sent to selected persons within educational institutions (professors, heads of departments, responsible for curricular

development etc.). The responsiveness of the surveyed educational institutions can be assessed as moderate to low, given that, out of 52 questionnaires (sent from 19 July until 5 August 2024) until 9 September 2024, 27 of them sent their responses with filled-in questionnaires – **51.9% of total number of Q1 sent.** The main reason for this not very good responsiveness were, most probably, the period of academic vacation (from mid-July to mid-September), which entirely coincided with the time when this research was carried out.

Geographical distribution of surveyed individuals and institutions was intended to be global, covering equally all continents. However, the response of European entities was disproportionally higher (34% of sent and 61% of received answers), most probably due to varying periods of academic vacation, as well as proximity and/or common fields of interests with the surveyor.

Q1 and Q2 were designed in a way that allows to display both common (some identical or similar questions) and specific standpoints of researchers and educators/representatives of educational institutions. This approach allowed to differentiate general (sub-chapter 5.1) and specific results (sub-chapters 5.2. and 5.3.), allowing further extrapolation. Some of the inquiries, even if formulated in a similar or identical way in both questionnaire (for example, Q1 - question 6 and 7 and Q2 – questions 8 and 9; Q1 - question 12 and Q2 - question 10) were introduced as a corrective variable, and will be presented separately in sub-chapters 5.2. and 5.3.

5.1. General results of the surveys (both Q1 and Q2) can be classified in three major topics:

1) general aptitude of AI-based tools to significantly improve education, learning and teaching methods;

2) actual use of AI to improve the education on climate change mitigation and its impact;

3) future potential of AI-based tools to significantly contribute to education and/or awareness-raising on climate change mitigation, adaptation, impact reduction and early warning.

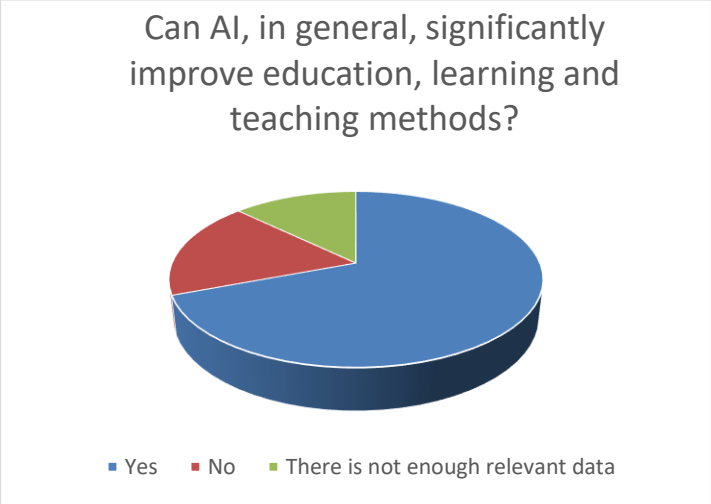


Chart 1.

5.1.1. While it is not surprising that, to a question formulated in general (and, to some extent, deliberately imprecise terms) the majority (72%) of surveyed entities responded positively, it is important to note that 13% of researchers and educators still consider that there is not relevant data regarding the potential of AI to represent a game changer in education (see Chart 1).

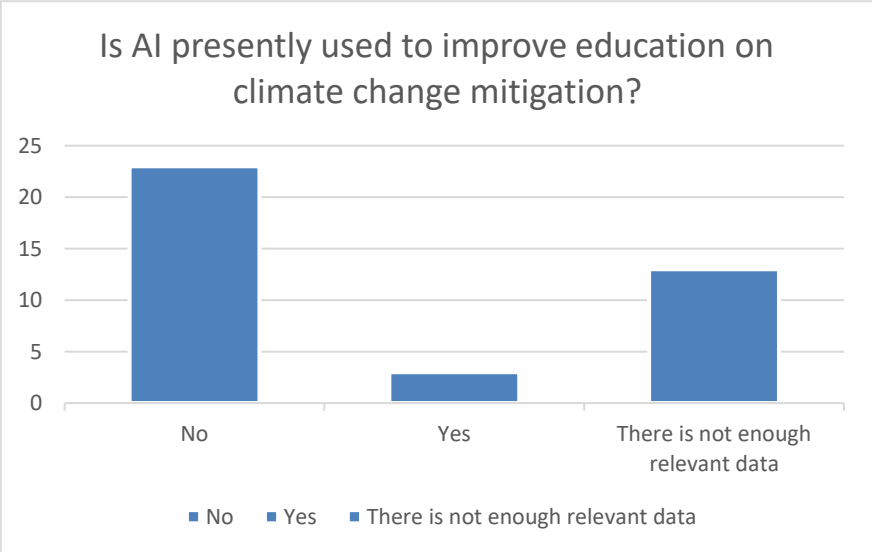


Chart 2.

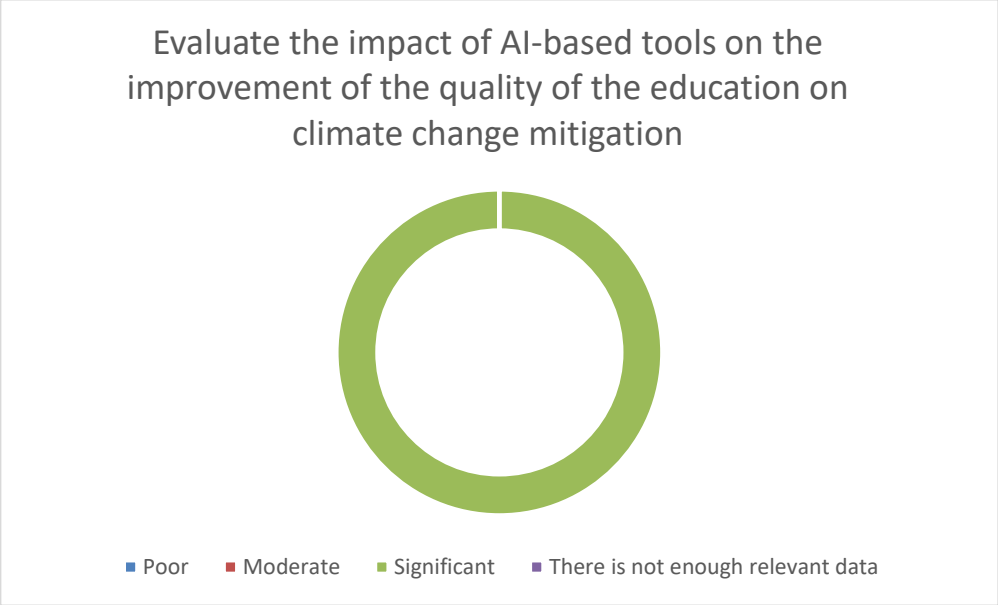


Chart 3.

5.1.2. The survey shows a significant discrepancy between (although quite general) trust that AI could improve education (67%), on the one hand, and the absence of its use in education on climate change mitigation (59%), on the other, with a significant share (33%) of those who declared that there is not relevant data (see Chart 2). However, out of the small proportion (7,7% - 3 out of 39) of those who consider that AI is presently used to improve education on climate change, everyone estimated that the positive impact of AI-based tools on the improvement of the quality of the education on climate change mitigation was significant (see Chart 3).

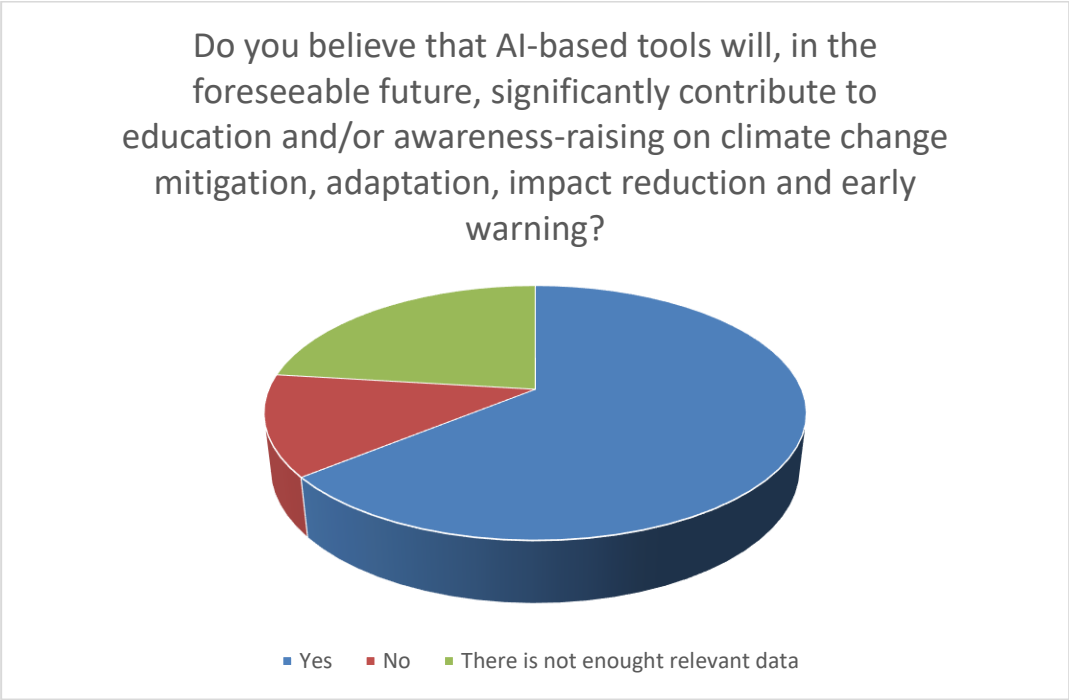


Chart 4.

5.1.3. However, even if very few of researchers and educators estimated that AI tools are actively used in education on climate change mitigation, majority of them (64%, see Chart 4) believe those tools will, in the foreseeable future, give a significant contribution to education and/or awareness-raising on this particular issue. This shows **that there is an important potential for future development of adapted, tailor-made, innovative and responsive AI-based tools that would be able to rapidly respond to the pressing need to reach educational goals in the field of education and awareness-raising on climate change**.

5.2. Survey among researchers was focused on the following three major specific issues:

1) number, scope, depth and frequency of modifications in curricula related to the use of AI tools in education on climate change mitigation[20];

2) level of interoperability of AI-based educational tools on climate change mitigation in technical, natural (biology, chemistry) and social sciences (political science, law, environmental studies) in the existing higher education curricula;

3) number and scope of proposed, adopted and/or implemented national and supra-national regulatory changes intended to improve the achievement of SDG

[20] While both researchers and educators were asked about the number and scope of these modifications, only researchers responded to the questions on their depth and frequency. This choice – combined with more detailed answers given to questions 13 (Q1) and 11 (Q2) – allowed differentiation and better results of extrapolation presented in Chapter 6 of this paper.

(Sustainable Development Goals) target 13.3 (Improve education, awareness raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning).

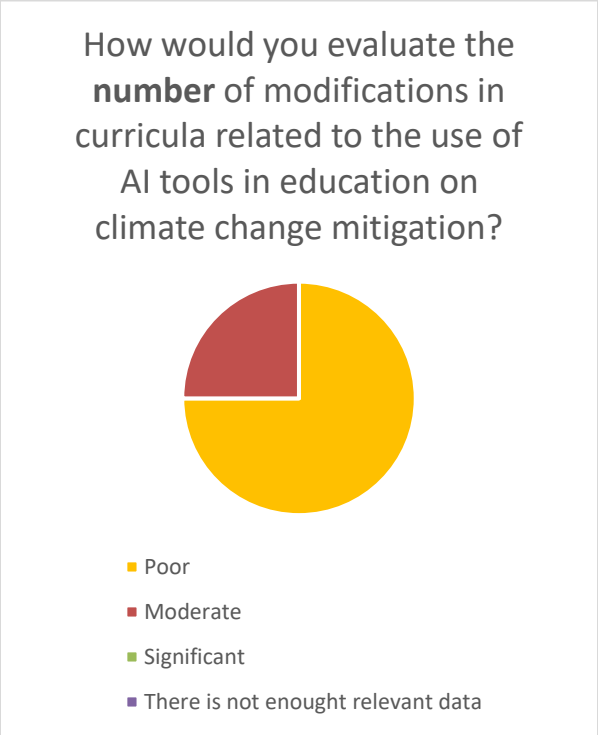


Chart 5.

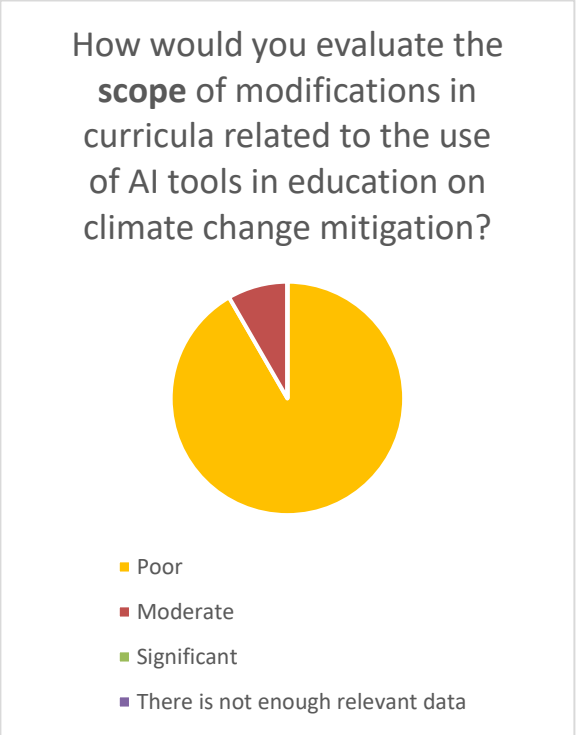


Chart 6.

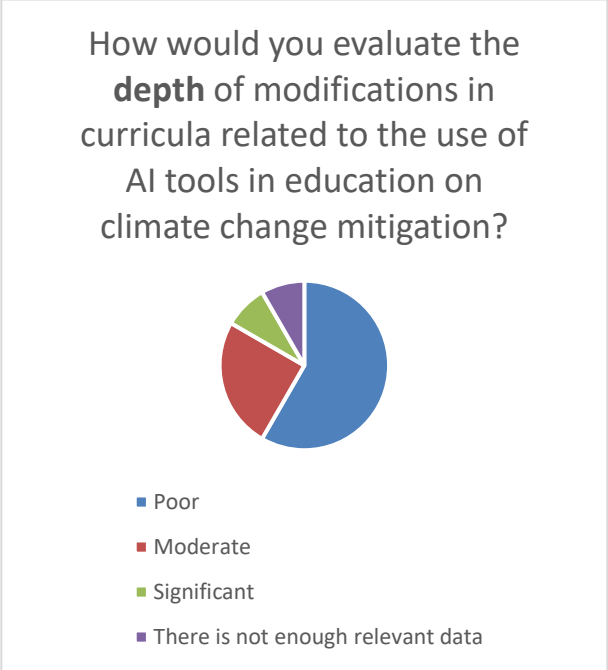


Chart 7.

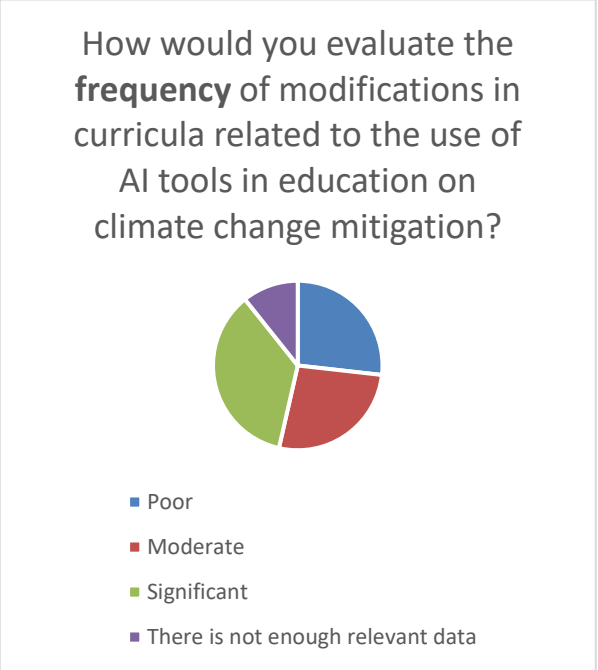


Chart 8.

5.2.1. It should be noted that, **even if they estimate that AI is rarely used to improve education on climate change mitigation (Chart 2), researchers believe there are some modifications in curricula in this direction**; while the number and scope of these modifications remain low (Charts 5 and 6), when they occur, they frequency (Chart 8) and, even more, depth (Chart 7) and not negligible.

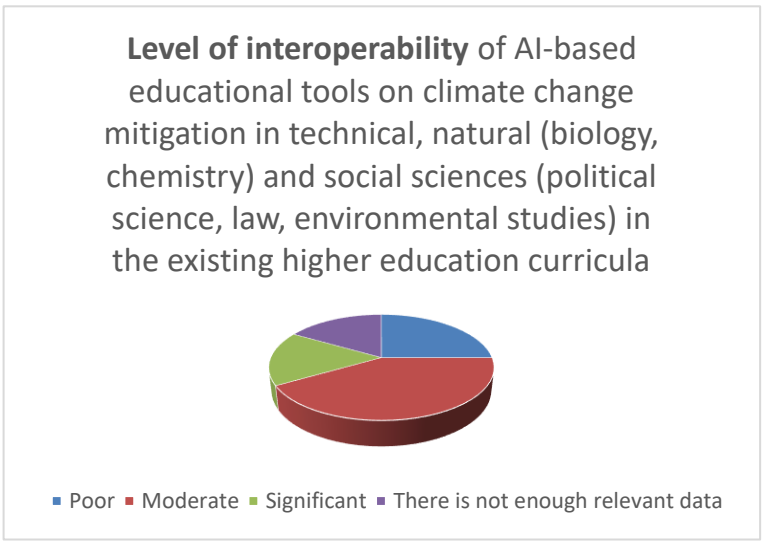


Chart 9.

5.2.2. The majority of researchers estimated that **the level of interoperability of AI-based educational tools on climate change mitigation (Chart 9) is moderate (42%) or significant (17%)**. If correlated with, on the one hand, their assessment regarding the depth and frequency of curriculum changes in this field (Charts 7 and 8), and, on the other, the time needed to fully implement them (Smeed et all., 2015) and allow "cognitive restructuring" (Lewin, 1951) it can be concluded (projection for 2024-2030) that AI-based educational tools will contribute to a significant complementarity and convergence of curricula dedicated to climate change in technical, natural and social sciences. Consistently implemented in higher number of curricula, this complementarity could significantly contribute to a positive impact of AI-based tools on the achievement of SDG target 13.3.

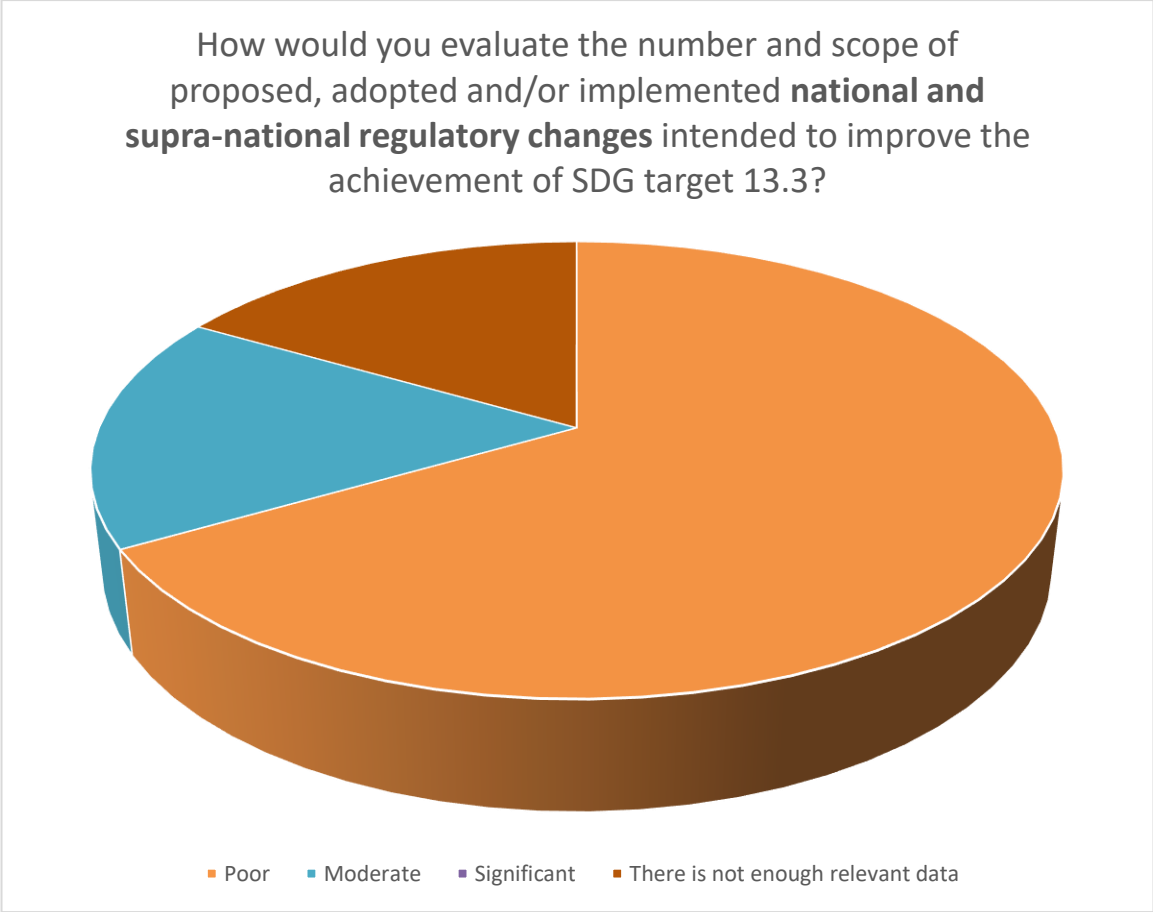


Chart 10.

5.2.3. Finally, in a question exclusively dedicated to them, the researchers were asked to give their estimation regarding national and supra-national regulatory changes aiming to improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning (SDG target 13.3). As one of the rare queries in Q1 not related to AI issues, it served bot as a control variable and as a way to compare results in curricular and regulatory changes. Finally, it is important to note that only a relatively small proportion of surveyed persons are experts in legal or political sciences, but – unlike it was the case of their answers presented in Charts 7, 8 and 9 – none of them invoked the absence of relevant data. Participants' responses to this question revealed an important finding: **researchers often consider themselves better informed about what is done on national and supra-national regulatory level than about what is done in the milieu of education.**

5.3. Survey among educators/representatives of educational institutions was focused on the following three major specific issues:

1) use of AI-based tools in educational and/or research activities;

2) presence of AI-related issues in curricula and/or institutional educational/research objectives;

3) number and scope of modifications in curricula related to the use of AI tools in education.

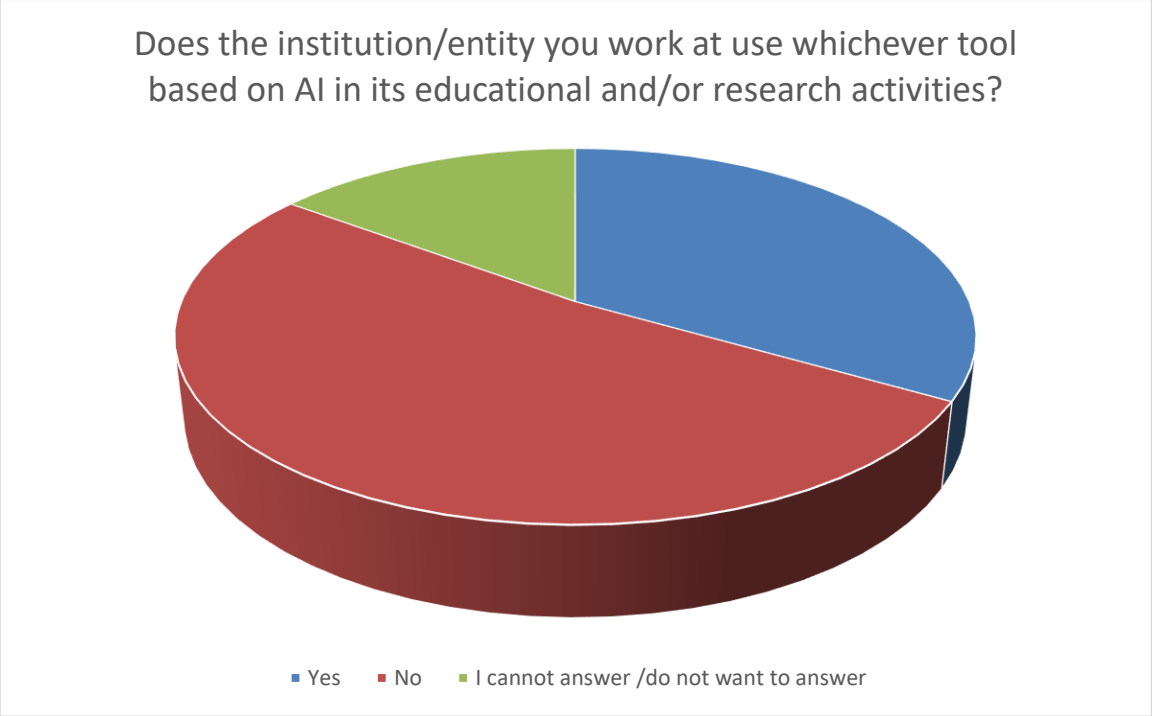


Chart 11.

5.3.1. **The use of AI in educational and/or research activities is still not widespread (33%) in educational institutions**, both on graduate and under-graduate level (Chart 11). It is, however, interesting to note that – even within their own institution – educators are often unaware (15%) of whether their colleagues in other departments/units are using some AI-based tools, and even less when it comes to the ways of this use. This shows that AI – at least on the global level – is still a novelty in educational milieu.

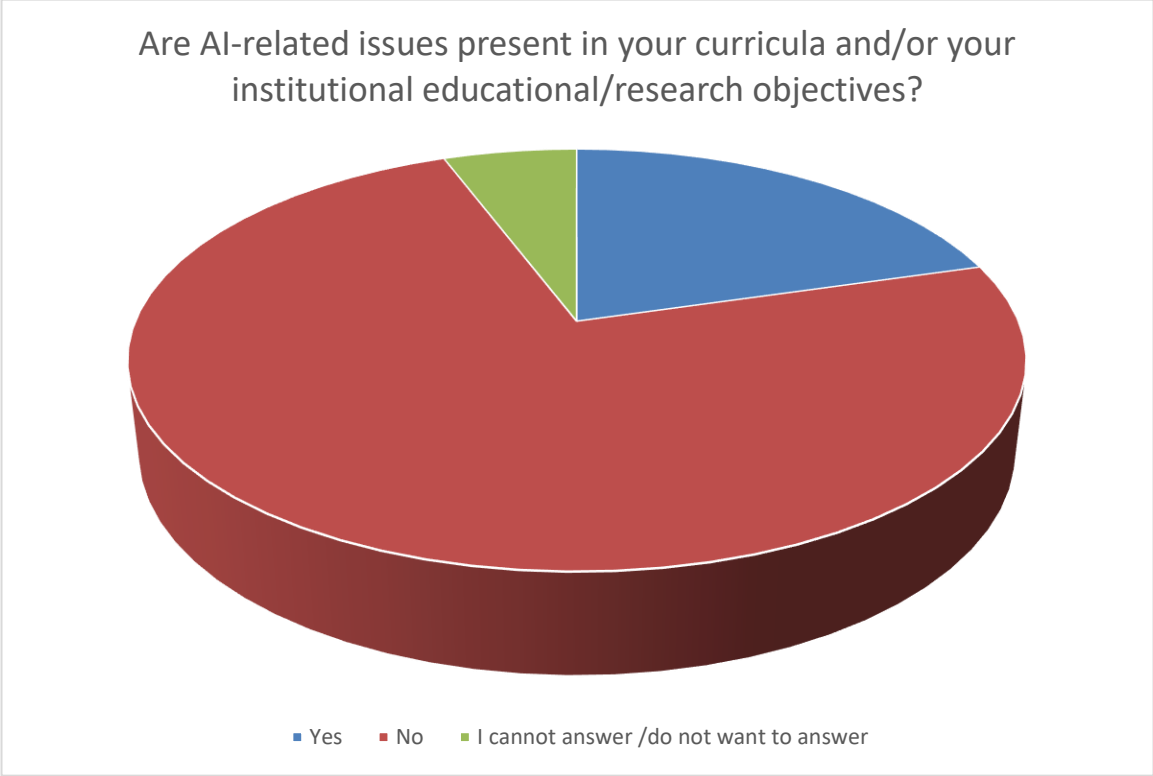


Chart 12.

5.3.2. The results were even more striking when educators had been asked about the presence of AI-related issues in curricula and/or institutional educational/research objectives of their institution (Chart 12). **The overwhelming majority (74%) responded negatively**, while those who stated that AI has – in a transparent and formally established way – its place in their curricula and/or among their institutional educational/research objectives were, most probably, professors who, themselves, designed those curricula and are presently teaching according to them.

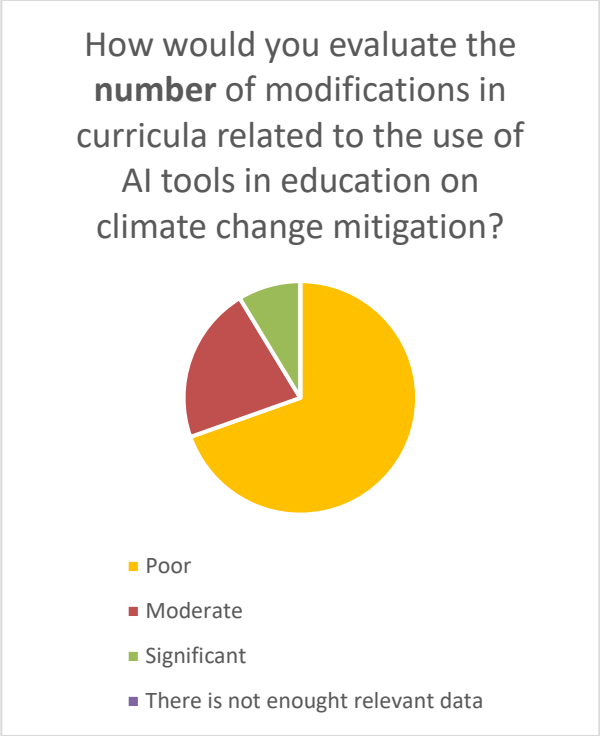


Chart 13.

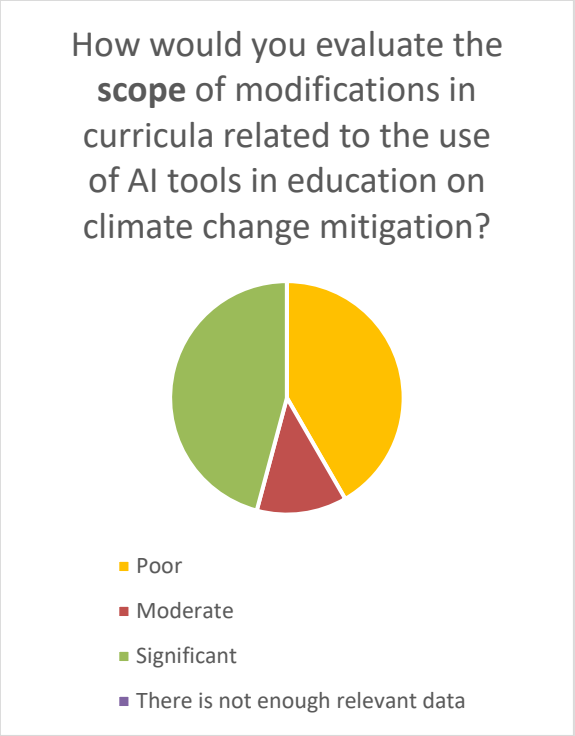


Chart 14.

5.3.3. It is very important to note that, while they are almost as pessimistic as researchers when it comes to the number of modifications in curricula related to the use of AI tools in education (Chart 13), educators' answers are outstandingly different regarding the scope of these modifications (Chart 14), with 55% of them estimating they are significant (42%) or moderate (13%). This leads to, most probably, the crucial insight of this part of survey: once the curriculum changes related to the use of AI tools in education on climate change are undertaken, their scope is, most often, significant. When put in correlation with what has already been alleged in sub-chapter 5.2.2., **it can be concluded (projection for 2024-2030) that AI-based educational tools have a significant potential to contribute to the achievement of SDG target 13.3.**

6. Conclusions and projections

On the basis of cumulative extrapolated elements obtained by surveys (Chapter 5) and analysis of the research on AIED and its applicability in education on climate change mitigation – ECCM (Chapter 3), combined with major insights on education-related elements of prohibited AI practices according to EU's AIA (Chapter 4), the following main conclusions and projections can be made:

1. **AI-based tools** can significantly improve education, learning and teaching on climate change mitigation, but they are **still relatively rarely used**;
2. **number and scope modifications in curricula related to the use of AIED tools in ECCM remain relatively low** (respectively, 72,5% and 68% in averaged values for researchers and educators), **while their depth** (in 33% of cases estimated as moderate and significant) **and, even more, frequency** (63%) **allow to predict (2024-2030) more substantial inclusion of AI-based tools and practices in ECCM curricula**;
3. **number and scope of proposed and/or implemented national and supra-national regulatory changes intended to improve the achievement of SDG target 13.3 remain poor**, while the belated adoption of EU's AIA and its timid regulatory choices will, most probably, lead to its limited effects and/or significant problems in its future enforcement in the EU Member States;
4. **the level of interoperability** – presently, estimated as moderate (42%) or significant 17%) – of AI-based educational tools on climate change mitigation in natural (biology, chemistry) and social sciences (political science, law, environmental studies) **will continue to grow** (2024-2030), contributing to the higher sustainability of pedagogic objectives in education on climate change mitigation;
5. taking in consideration the specific needs and characteristics of ECCM (*see Table 1 below*), such as cross-disciplinarity, high global socio-economic stakes exigency to reach educational goals, **AI-assisted educational tools adapted to ECCM (projection 2024-2030) are far more susceptible to reach pedagogic goals than general AI-based tools**, because:

   5.1. their cross-disciplinarity allows to better illustrate the complexity of sustainability related issues;

   5.2. they are:

   - capable to present the societal impacts of climate change;
   - efficient in combatting prejudices, misbelieves and conspiracy theories; and
   - responsive to new channels of information and communication;

   5.3. they are faster, given their aptitude to provide concise and tailor-made training;

   5.4. they are more efficient in raising consciousness and encouraging environmental activism.

Table 1.

SPECIFIC NEEDS/CHARACTERICTICS OF ECCM	Traditional (non AI-assisted) curricula	General AI-assisted educational tools	AI-assisted educational tools adapted to ECCM (projection)
cross-disciplinarity	Low to moderate - frequently insist on strict division between natural and social sciences - slow in adaptation to cross-disciplinary issues related to sustainability	Moderate - more often integrate cross-cutting issues - often include interactive educational tools	Moderate to high - able to illustrate the complexity of sustainability related issues - always include interactive educational tools
high global socio-economic stakes	Weak adaptability - mostly slow and inefficient in combatting prejudices, misbelieves and conspiracy theories about climate change - irresponsive to new channels of information and communication	Adaptable, with high risks - adaptable to quick societal changes and rapidly changing environment - can easily be used for deceptive and manipulative purposes	Highly adaptable - capable to present the societal impacts of climate change - efficient in combatting prejudices, misbelieves and conspiracy theories - responsive to new channels of information and communication
exigency to reach educational goals	Mainly slow - most often designed to reach complex educational goals - focused on long-lasting pedagogic objectives	Potentially rapid, with risks - can deliver rapid outcomes, with questionable sustainability - can be subject to manipulation	Rapid - capable to provide concise and tailor-made training - efficient in raising consciousness and encouraging environmental activism

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ANNEXES

QUESTIONNAIRE 1

****

Please answer to the questions No. 1, 2, 4, 6, 7, 8, 10, 12 and 15 by choosing one of the offered answers (put the sign X in the appropriate box).
For questions No. 3, 5, 11, 13, 14 and 16, please provide a brief answer, citing, if necessary, the relevant sources and/or other information you consider relevant.

****

Question 1: According to you and on the basis of the research you have conducted and/or of your professional experience, does the Artificial Intelligence (AI), in general, have a significant aptitude to serve as a tool in improving education, learning and teaching methods?

Yes	
No	
There is not enough relevant data	

Question 2: According to your best knowledge, has the AI, until now, been used to improve the education on climate change mitigation?

Yes	
No	
There is not enough relevant data	

Question 3: If your answer to the previous question is yes, please cite the most outstanding examples.

_____
_____
_____

Question 4: If your answer to the question No. 2 is yes, please evaluate the impact of AI-based tools on the improvement of the quality of the education on climate change mitigation.

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 5: If, in the previous question, you have opted for the answers "poor", "moderate" or "significant", please briefly motivate your choice.

_____
_____
_____

Question 6: How would you evaluate the number of modifications in curricula related to the use of AI tools in education on climate change mitigation?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 7: How would you evaluate the scope of modifications in curricula related to the use of AI tools in education on climate change mitigation?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 8: How would you evaluate the depth of modifications in curricula related to the use of AI tools in education on climate change mitigation?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 9: How would you evaluate the frequency of modifications in curricula related to the use of AI tools in education on climate change mitigation?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 10: How would you evaluate the number and scope of proposed, adopted and/or implemented national and supra-national regulatory changes intended to improve the achievement of SDG (Sustainable Development Goals) target 13.3 (Improve education, awareness raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning)?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 11: If, in the previous question, you have opted for the answers "moderate" or "significant", please cite some examples of proposed, adopted and/or implemented national and supra-national regulatory changes and briefly provide the relevant information on them.

_____
_____
_____

Question 12: Please evaluate the level of interoperability of AI-based educational tools on climate change mitigation in technical, natural (biology, chemistry) and social sciences (political science, law, environmental studies) in the existing higher education curricula?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 13: If, in the previous question, you have opted for the answers "poor", or "moderate", please explain briefly how the above-mentioned interoperability can be improved.

_____
_____
_____

Question 14: Please briefly explain your understanding of the impact of AI on education, in general.

_____
_____
_____

Question 15: Do you believe that AI-based tools will, in the foreseeable future, significantly contribute to education and/or awareness-raising on climate change mitigation, adaptation, impact reduction and early warning?

Yes	
No	
There is not enough relevant data	

Question 16: If your answer to the previous question was "yes", what are, according to you, the main opportunities and threats of the use of various AI-based tools in education and, in particular, in education on climate change mitigation?

_____
_____
_____

Thank you for taking time to answer this survey!

QUESTIONNAIRE 2

****

Please answer to the questions No. 1, 2, 3, 4, 6, 8, 9, 10 and 13 by choosing one of the offered answers (put the sign X in the appropriate box).

For questions No. 5, 7, 11, 12 and 14, please provide a brief answer, citing, if necessary, the relevant sources and/or other information you consider relevant.

****

Question 1: According to your best knowledge, does the institution/entity you work at use whichever tool based on AI (Artificial Intelligence) in its educational and/or research activities?

Yes	
No	
I cannot answer /do not want to answer	

Question 2: Are AI-related issues present in your curricula and/or your institutional educational/research objectives?

Yes	
No	
I cannot answer /do not want to answer	

Question 3: According to you, does the Artificial Intelligence (AI), in general, have a significant aptitude to serve as a tool in improving education, learning and teaching methods?

Yes	
No	
There is not enough relevant data	

Question 4: According to your best knowledge, has the AI, until now, been used to improve the education on climate change mitigation?

Yes	
No	
There is not enough relevant data	

Question 5: If your answer to the previous question is "yes", please cite the most outstanding examples.

_____

_____

_____

Question 6: If your answer to the question No. 4 is "yes", please evaluate the impact of AI-based tools on the improvement of the quality of the education on climate change mitigation.

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 7: If, in the previous question, you have opted for the answers "poor", "moderate" or "significant", please briefly motivate your choice.

_____
_____
_____

Question 8: How would you evaluate the number of modifications in curricula related to the use of AI tools in education on climate change mitigation?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 9: How would you evaluate the scope of modifications in curricula related to the use of AI tools in education on climate change mitigation?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 10: Please evaluate the level of interoperability of AI-based educational tools on climate change mitigation in technical, natural (biology, chemistry) and social sciences (political science, law, environmental studies) in the existing higher education curricula?

Poor	
Moderate	
Significant	
There is not enough relevant data	

Question 11: If, in the previous question, you have opted for the answers "poor", or "moderate", please explain briefly how the above-mentioned interoperability can be improved.

_____
_____
_____

Question 12: Please briefly explain your understanding of the impact of AI on education, in general.

_____
_____
_____
_____

Question 13: Do you believe that AI-based tools will, in the foreseeable future, significantly contribute to education and/or awareness-raising on climate change mitigation, adaptation, impact reduction and early warning?

Yes	
No	
There is not enough relevant data	

Question 14: If your answer to the previous question was "yes", what are, according to you, the main opportunities and threats of the use of various AI-based tools in education and, in particular, in education on climate change mitigation?

_____
_____
_____

Thank you for taking time to answer this survey!