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Discussing UX, Human Factors/Ergonomics and Design for autonomous intelligent educational systems

Discutindo UX, Ergonomia e Design para os sistemas educacionais inteligentes autônomos

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Abstract

Several autonomous solutions based on data collection and Artificial Intelligence (AI) are being used in many fields. Despite the time, cost, and scale benefits they bring, what are the possible implications of their use in a complex area like Education? The so-called Edtech, through technologies such as Intelligent Tutoring Systems and Adaptive Learning Platforms, is evolving to become able to record, assess, and predict students' cognitive and emotional behavior and thereby provide personalized answers and learning paths to learners, with little or no human involvement. Many authors problematize this scenario, pointing out doubts and inconsistencies in, for example, treating the subjective process of human formation in an essentially mathematical, objective way. Considering the fundamental social role of Education, this paper proposes a (self) critical discussion: in a human-centered approach, what are the implications for Design, UX, and Human Factors/Ergonomics professionals when designing and evaluating these systems? Being Education so complex and delicate, are the ongoing debates about AI in these three fields enough? Or do we need to rethink them specifically for autonomous and predictive learning?

Keywords: Edtech; Artificial Intelligence; Ergodesign; Education; UX

Resumo

Em muitos campos, cada vez mais se pesquisa e usa soluções autônomas baseadas em coleta de dados e Inteligência Artificial (IA). Apesar de benefícios de tempo, custo e escala que trazem, quais suas possíveis implicações num campo complexo como o da Educação? A chamada Edtech, através de tecnologias como os Sistemas de Tutoria Inteligente a Plataformas Adaptativas, evolui para se tornar capaz de registrar, avaliar e prever o comportamento cognitivo e emocional dos alunos e, com isso, fornecer respostas e trilhas de aprendizagem personalizadas com pouca ou nenhuma participação humana. Muitos autores problematizam esse cenário, apontando dúvidas e incongruências em, por exemplo, se tratar o processo subjetivo de formação do ser humano de uma forma essencialmente matemática, objetiva. Levando em conta a importância fundamental da Educação na construção social, este artigo propõe uma discussão (auto) crítica: numa visão centrada no ser humano, quais as implicações para

profissionais de UX, Ergonomia e Design ao projetar e avaliar esses sistemas e soluções? Sendo a Educação tão complexa e delicada, os debates em andamento nesses três campos sobre o cenário da IA são suficientes? Ou precisamos repensá-los especificamente para uma aprendizagem autônoma e preditiva?

Palavras-chave: Edtech; Inteligência Artificial; Ergodesign; Educação; UX

1. Introduction

Adapting technology to human nature is the primary concern of Human Factors/Ergonomics (HF/E), Human-Computer Interaction (HCI), and Usability Engineering (HASSENZAHL, 2008). But what is "human nature"? It is often seen narrowly in terms of perception, cognitive processes, and performing efficiently. That way, technology would be characterized as a tool to save time and do things in a pleasurable way. Some question that technology use, by itself, can also be a source of pleasure, going beyond the performance of tasks (HASSENZAHL, 2008). But, could technology also be a source of displeasure? If perception, stimulation, social exchange, feelings, and experiences are underlying motives and outcomes of technological use (HASSENZAHL, 2008), systems that do not consider all dimensions of human nature can bring negative experiences that accumulate and become worsen over time.

Edtech (Educational Technology) refers to the use and integration of technological devices in Education, which establishes a connection between traditional learning and real-world experiences, enabling students to meet the challenges of an economy that values innovation and leadership (MENDONÇA NETO; VIEIRA; ANTUNES, 2018). Many of these technologies can process autonomous, real-time analysis of large streams of data seized into their systems. This would allow personalization of learning processes and assistance of teachers, by predicting students' reactions and by performing simpler or more tedious teaching tasks. Thus, enhancing the experience for all involved.

But what is "experience"? HF/E, Human-Computer Interaction (HCI), Human Centered Design (HCD) and User Experience (UX) research and may contribute, in correlated ways, to the discussions and approaches that these autonomous educational systems may bring. This paper seeks to show that even though designers and ergonomists are already studying and debating technologies powered by Big Data and Artificial Intelligence (AI), Education may need a more specific and careful approach. To this end, the paper begins by presenting challenges brought by Artificial Intelligence to UX, Human Factors/Ergonomics and Design. Next, the paper cuts to AI used in Education. Studies show that these technologies are increasingly being used in teaching and learning, personalizing educational processes by collecting cognitive and emotional data. In this scenario, what can be the changes in Education? And in society, as a whole? Finally, this paper questions: within what is thought so far of UX, HF/E and Design in AI-focused debates, how to approach this new Education? In a human-centered view, what should be the care of designers and ergonomists when designing and evaluating these systems? Considering the long-term effect of Education on social structuring, can or should designers evaluate these

systems only when the product is being built, launched or upgraded? Or would it require an iterative, continuous and systemic evaluation to identify negative effects over the years? The purpose of this article is to look for and point to possible ways that might help answer some of these questions.

2. The challenges of Artificial Intelligence for UX, Design and Human Factors/Ergonomics

The basic problems that most AI systems try to solve relate to predicting an outcome. The tool for making that is an algorithm - the set of rules that a machine follows to solve a problem. A Machine Learning (ML) system, for example, is often composed of layers of models, services, companies, and infrastructures, one on top of the other (CRAMER; KIM, 2019), that need human judgment to define approaches, evaluate qualities, and override problems. That way, what is the right level of labor separation between AI and humans? In which cases can one have, or not, (almost) complete autonomy? Xu (2021) emphasizes that in the "smart" age, autonomy refers specifically to the ability of AI-based autonomous systems to perform specific tasks independently. These machines can exhibit behaviors and "evolve" until gaining certain cognitive and adaptive abilities close to humans'. They can operate successfully in situations not fully anticipatable, and the results may not be deterministic. However, in everyday use, there will be situations that designers had never considered and which the system cannot control (XU, 2021). For Zimmerman et al. (2021), AI innovations such as predictive analytics, advanced decision support, and next-action recommendations attract attention. Still, they can have high costs and risks without the right skills and conditions.

There is also a lack of content about Design and UX decisions that interfere with AI feedback loops between users, communities, and systems. This can lead to erroneous solutions for different contexts (CRAMER; KIM, 2019). Also, many ML algorithms are difficult to explain, making it opaque to understand their influence on outcomes (especially those more sensitive to humans, such as granting pensions or healthcare). Xu (2019) says that ML learning processes are not transparent, and the outcome of AI-based decisions is not intuitive. So, if techniques have become more accessible, developers with little training and awareness can easily deploy harmful but powerful products (CRAMER; KIM, 2019).

Artificial Intelligence practitioners must manipulate a variety of goals from users, content creators, and decision-makers. They are trained to find the best model that maximizes some utility. However, there is rarely a single goal to be maximized, while many cannot be easily quantified (CRAMER; KIM, 2019). Relating autonomy to automation (a system's ability to perform well-defined tasks and produce deterministic results, without quasi-human "intelligent" capabilities and based on a fixed set of rules), Xu (2021) reinforces that, in both cases, complex systems are fragile when dealing with unforeseen situations, surprising human operators who do not understand what the system is doing and why.

To design usable and "human" AI, one must go beyond mere interaction. The human-machine relationship has moved from human-computer interaction to human-machine integration and human-machine partnership, where humans and systems are teammates and collaborative partners - a dynamic cooperation between two cognitive agents with the ability to learn over time (XU, 2019). This scenario brings several issues that require systematic research in areas such as HCI, Design, and HF/E. One concern that must be present is that any person or thing that learns, also inevitably fails. However, In the AI context, failures are often productive (CRAMER; KIM, 2019).

These points reinforce the importance of designing AI to cause the least harm; to think designs and processes collectively; and to involve professionals from various fields. The AI frontier is not only technological, but also humanistic and ethical. It should improve humans, not replace them (XU, 2019). And that makes one wonder if the present quest for automation of certain educational processes is not rushed and dangerous.

Feng and Law (2021) point out that challenges of Artificial Intelligence in Education include implementation, practical effects of AI systems in cross-cultural global learning settings, and issues of privacy, scalability, and system effectiveness. Technology can likely facilitate many educational processes. However, care and questioning are necessary for it to be done with balance.

3. Education and autonomous intelligent systems: what may (or may not) happen?

Mendonça Neto, Vieira, and Antunes (2018) sought to differentiate Education and teaching. Education would be the set of processes that prepare a human to play his role in society and comprise his intellectual development and physical, moral, and aesthetic formation. Teaching would be the knowledge transmission process with its vicissitudes. Thus, choices in teaching processes, for whatever reasons (pedagogical, economic, political), inherently influence the human aspect. In the long run, it can shape society's physical, moral, and intellectual development. These are choices that impact those directly involved and potentially all human beings. In this sense, given the doubts that still surround technologies based on AI and Big Data, much care and attention is needed when using them in educational situations. Particularly, tools that seek to autonomously predict, measure, and label students' cognitive and emotional behavior.

Guo et. al (2021) identify that, as neural network algorithmic advances in the mid-2000s, deep ML processes have become more attractive within educational AI. Recently, algorithms have specialized in facial, voice and text recognition. They have begun to be widely applied to Education through research on optimized Intelligent Tutoring Systems, model designs, and parameter values. On the positive side, AI technologies powered by Big Data would enable a continuous flow of data that details many aspects of the user experience. Information would flow differently, from company to user, enabling person-specific solutions and constantly

improving experiences in real time (VERGANTI; VENDRAMINELLI; MARCO, 2020). They would promote personalized learning, provide real-time analytics, use self-adaptive content, and assign targeted practice. They would also identify changes in cognitive state during learning processes by analyzing student data and predicting future performances (GUO et al., 2021). They are said to lower the barrier some feel in revealing private thoughts to humans in reflective texts (ULLMANN, 2019; RICHMAN et al., 1999). Students would also be less subject to "human bias", the inherent imperfection of *Homo Sapiens* present in teachers and tutors. For all that, digital technologies are associated with enhanced ways of accomplishing tasks (SELWYN, 2011).

Researchers such as Vicari (2018) - who conducted a systematic review of the literature and patent bases on the subject in countries such as the US, the European Union, Canada, and Brazil - identify several current and potential functionalities that illustrate Edtech trends. Among technologies that use AI, there are Intelligent Affective Tutoring Systems (ITS), which use it for personalization of teaching and detection of the student's emotional state; Learning Management Systems (LMS); Intelligent Educational Robotics; and Massive Open Online Courses (VICARI, 2018). Feng and Law (2021) reviewed 1,830 research articles between 2010 and 2019. Their results confirmed that "Intelligent tutoring system" and other keywords such as "natural language processing," "educational data mining," and "student modeling" had high popularity throughout the time analyzed (FENG; LAW, 2021). One perceives, then, a trend toward developing systems based on learners' cognitive and emotional measurement, with increasing capacity to perform human tasks autonomously (Table 1). Feng and Law (2021) further noted that the technical focus was mostly on natural language processing, educational data mining, Learning Analytics, and Machine Learning, with highly influential keywords in the field. Of course, it is not yet possible to say how and to what extent these systems will perform "in classroom", but it is a trend that is already noticeable and will hopefully be in mainstream use by 2030 (VICARI, 2018).

So, what are the risks of autonomously "labeling", through algorithms, people's cognitive and emotional profile? Are learning and assessment a simple matter of transmitting information and mathematically measuring its absorption? For now, it is argued that these systems and tools will only be assistants, without ever replacing teachers. But what about when this technology gets cheaper than hiring people?

Mendonça Neto, Vieira, and Antunes (2018) say that one cannot reduce the definition of learners to the single functional dimension of future economic agents. We must have socially integrated individuals, "aware of their possibilities, driven by the desire to know and learn constantly." Is learning a product or a process? Selwyn (2011) recalls that many theories see learning as a product, where the result are "gaining knowledge" and "filling empty vessels."

With data-based assessment, control over life no longer comes from social relationships and interaction mediated by natural languages but by algorithms and computational systems. This affects not only cognitive abilities but also ethical relationships, emotional abilities, and aesthetic sensibilities (BANNELL, 2017). People spontaneously think while acting much more

often than one might think. Thus, much of cognition may not fit into mental models, but would result of more direct contact with the world (BANNELL, 2017). Leaving it up to machines to direct the learning process would ignore the role of the biological body in cognition, which cannot be codified and elaborated in algorithms. Moreover, minds would be situated not only in bodies, but also in sociomaterial practices (cultural and physical artifacts). Cognition would be distributed between human and non-human actors (BANNELL, 2017).

Table 1 – Some technologies being used and/or researched in the EdTech context

Computer vision	image recognition; face recognition; recognition of emotional aspects
Computational creativity	autonomous generation of creative examples and exercises to enrich content; recognition of students' creative activities
Computer ethics	Personal Learning Assistants with personalities to suit each student, seeking to encourage ethical principles.
Learning ecosystems	Integration of educational systems through characteristics and information sharing
Collaborative learning	Collaboration between students to solve problems; A.I. tools that enable collaboration in virtual environments.
Personalized Teaching / Learner Model	Gathers information from the learner's affective and cognitive model to generate challenges, content, and assessments based on the learner's knowledge and emotional state.
Autonomous decision making	Autonomous ability to choose/decide what the next step in the system will be. Based on the learner's model (cognitive, affective, personality, performance)
Affective/emotional systems	Search, through AI, for detection and expression of emotions; recognition of affective states
Natural Language Processing	Making sense of written and spoken language; translation, language correction and generation, without human participation.

Source: based on VICARI, 2018

Artificial Intelligence tends to reflect the information used to train or feed it. As O'Neil (2016) reminds us, these applications and algorithms are based on choices made by fallible humans: however good their intentions, "many of these models encode misunderstandings and biases". They are sometimes complex to the layman, difficult to monitor, to enforce, and operate under legislation that does not address them. They are based on statistical decisions that generate mere probabilities, sometimes elevated to the status of certainties (O'NEIL, 2016). Finally, Artificial intelligence does not yet possess empathy. For that, they would have to experience and understand emotions, something complex even for humans. How can we leave crucial decisions about people in the hands of entities incapable of empathy and emotional understanding? For Bannell (2017), it would be a mistake. Automated learning would involve

building algorithms that can learn to make predictions and change their own configuration considering those predictions. Thinking requires semantics. A machine can use processes that simulate human deductive reasoning and inference. However, it does not "understand" what it is processing in the same way a human does when reading or interpreting images. Autonomous systems would determine learning and action based on past predictions embedded in algorithms, which could lead to standardization and the "obscuring of imagination and the invention of the new" (BANNELL, 2017).

O'Neil (2016) reminds us that this technology "free from human bias" is nothing more than a model, an abstract representation of a process, a simplification. And that it is created through choices of what is, or not, important enough. Models and systems reflect goals and ideology. Values and desires influence the data collected and questions asked. "Models are opinions embedded in mathematics" (O'NEIL, 2016).

When measuring and trying to predict students' cognitive profile and behavior, are contextual issues around them being considered? If the computer "decides" what the student will see next, based on his performance, who evaluates that performance and who makes the decision, and based on what criteria? The evaluation ignores the student's feelings about their own performance (BANNELL, 2017). Selwyn (2011) points out that we need to consider the social milieu of education: not only policies and organizational culture of institutions (schools, colleges), but personal contextual issues (home, work, community) and general issues (economy), as they influence education. Hall (2017) problematizes that "institutional ecosystems" generate a range of data used for monitoring. This can impact student and staff well-being, as academic life and practice are increasingly prescribed from data-driven performance management, potentially bringing powerlessness and increased anxiety (HALL, 2017).

Selwyn (2019) points out that there is a fine line between being assisted and being supervised. Between being guided and being directed. A system that records and analyzes every conversation between students and teachers could be both a practice and a performance measurement tool. Teachers could lose control and autonomy over their production, forced to adjust to what the machines expect or just settling for what systems cannot do, making their work less worthy. Mendonça Neto, Vieira, and Antunes (2018) see Edtech adoption as a symptom of Education industrialization. These technologies would require management models based on calculability and efficiency, introducing systems that facilitate teachers' activities but also control and evaluate their performance via criteria such as a number of accesses, time spent online, and number of tasks requested from students. By their very design, these systems would induce pedagogical practice standardization to facilitate the replacement of professionals (MENDONÇA NETO; VIEIRA; ANTUNES, 2018).

What will be the teachers' new role? How does this change the act and philosophy of teaching? Could machines, at some point, make quality or safe decisions without any need for human assistance or evaluation? The issue is not about machines "stealing jobs". As Barreto (2017) says, it is not about changing the teachers, but the teaching work, with all its political and

practical consequences, to the point of reconfiguring the whole process, from training to professional practice.

In any case, Xu (2021) points out that the more automation is added to a system and increases its reliability, the less likely humans will be able to take over manual control when necessary or problematic. Therefore, autonomy may be likely to surprise human operators even more than is already seen in automation (XU, 2021). Even if teachers remain in classroom, is there the risk of them becoming mere "confirmers" of autonomous decisions? In the event of an error or problem, how many people, for how long, will be harmed before control can be taken over "manually"? Have teachers been or will they be invited to jointly "design" the algorithms that define their daily practice?

Human-Computer Interaction is a multidisciplinary field of study focusing on the interaction between humans and computers and almost all forms of information technology design (INTERACTION DESIGN FOUNDATION, 2021). Approaching this scenario through HCI, it could be said that Big Data helps determine correlations (where relationships exist), but not causality (why relationships exist). To do this, researchers would need to interact with smaller groups, gaining a deeper understanding of data meaning. Combining Big Data approaches with techniques such as interviews or focus groups could benefit such research by going beyond correlations and understanding causality as well (LAZAR; FENG; HOCHHEISER, 2012). One can reflect on autonomous educational systems in these same terms: without the human presence to capture and understand causation, wouldn't the analysis of the data and context be less complete or accurate?

Can such profound changes in the way we teach and learn, and the attempt to predict cognitive and emotional behavior, be made without long-term systemic thinking? Without making sure that people involved (in a way, all of us) have the best experience possible? How to "fix" a mistake in something of this magnitude? How can we compensate those who suffer because of this mistake? Thinking about these questions, one could quote Giacomin (2014), who says that interactions and meanings result from a communication and learning process that cannot be fully anticipated. Mendonça Neto, Vieira, and Antunes (2018) stress that EdTech requires care, such as appropriate time for elaboration, implementation, and development. They also reaffirm that short-term actions tend to fail in teaching and learning. Thus, what are the risks of designing without worrying or problematizing the long-term use of autonomous Edtech? Their social and individual effects cannot be predicted, either for "good" or "bad". Thus, shouldn't be undertaken a continuous and broad observation, beyond interaction and function, of these people's experience?

4. Thinking autonomous Edtech through HCI, UX, Human Factors/Ergonomics and Design

The Human Factors and Ergonomics Society (HFES) advocates the usage of knowledge about relevant human characteristics to achieve compatibility in interactive systems design, machines, environments, and devices, contributing to overall human well-being and quality of life (KARWOWSKI, 2012). For Dull et al. (2012), this ensures that designs, from a consumer product to an organizational environment, are shaped around human capabilities and aspirations. The IEA (International Ergonomics Association) defines Ergonomics/Human Factors as the scientific discipline concerned with understanding human interactions and other elements. It applies theories, principles, data, and methods to design and optimize human well-being and overall system performance (IEA, 2021).

Karwowski (2012) points out that contemporary HF/E looks at human behavior, abilities, limitations, and other characteristics for designing tools, machines, systems, tasks, jobs, and productive environments, seeking "safe, comfortable, and effective human use". However, Meister (1999) reminds that, to think of an ergonomic taxonomy about technology, it is necessary to consider its effect on the role and behavior of humans. For Hassenzahl (2008), an experience is a continuous reflection on events, a constant flow of internal conversation. Events would extend over time, with a definite beginning and end and a temporal dimension. This momentary sensation of pleasure and pain in varying intensities would always be part of experience, and the feeling of "good-bad" would regulate our behavior. But don't the events "echo" even after their "end"? Are we not the result of these events' effects, which accumulate over people? So, we need to think: in the autonomous Edtech case, will it be possible to measure the effect on humans and their "well-being", using only an approach that evaluates the immediate, momentary use and interaction with these systems? Some argue that technology popularization may trigger a revision of the current understanding of "well-being", as well as cognitive and system performance (DITTMAR et al., 2021). For Dull et al. (2012), when Ergonomics/Human Factors does not play a role in system design, there can be low quality and efficiency, illness, and dissatisfaction. In other words, a bad experience.

Forlizzi (2018) highlights that computing popularization demanded interfaces with usability and effectiveness that included entertainment and engagement, among other things. Thus, HCI should evolve to focus on Experience Design, which tries to understand users' needs in all areas of life. Xu (2019), meanwhile, proposes an expanded Human-Centered AI (HAI) framework, which would help deliver solutions not only ethical and technological, but also explainable, with understandable, useful, and usable AI. That could bring AI solutions that avoid discrimination, are fair, and reflect human intelligence without replacing it. AI research would need to promote a reorientation towards a human-centered approach in a broader context (XU, 2019).

Lazar, Feng, and Hochheiser (2017) recall that longitudinal studies, spanning years, are rare in HCI for reasons of complexity and technological change. But now, with the still unknown impact of Machine Learning applications, perhaps this needs to change. Hassenzahl (2008) asks: if UX is

a momentary evaluative feeling of interacting with a product or service, does it become a temporal phenomenon, present-oriented and changing over time? Would it shift attention from content and materials to subjective, human feelings? If so, he asks: how to track people's thoughts as they interact with a product? How to measure UX over time? How to evaluate unique and remarkable "moments"? How to integrate momentary feelings into a later, cumulative feeling or sense?

Wouldn't the paradigmatic changes that may come from these educational technologies require a human-centered approach that also considers possible future systemic effects? Couldn't it be considered preemptively, in some way, helping to avoid harmful applications? Couldn't their use be measured iteratively, readjusting and rethinking these technologies over time? Longitudinal approaches, involving case studies, observations, interviews, and data recording, might be better suited to understand the impact of these new educational systems on phenomena such as motivation, collaboration, social participation, trust, and empathy, which impact people on a societal level (LAZAR; FENG; HOCHHEISTER, 2017).

If, for HF/E, our performance in a system results from the compatibility between individual human characteristics and technological and contextual requirements and resources (KARWOWSKI, 2012), a systemic and continuous approach on Education and autonomous intelligent applications is fundamental. Suppose HF/E must pay attention to complex physical ("things"), organizational (how activities are organized and controlled) and social (other people, culture) environments where we interact with systems (DULL et al., 2012). In that case, it is necessary to think, analyze and design these technologies going beyond interfaces and interactions. Sanders and Stappers (2008) remind us that we are moving from designing for categories of "products" to designing for the purposes of people. Similarly, Forlizzi (2018) points out that one needs to go beyond User-Centered Design (UCD) and UX and consider that is designing services. Almost everything being made would be a service or platform, designed for various stakeholders to interact with. Services are distinct from products because they are systemic, designed for multiple stakeholders. Services need a broader design approach. People would need to be considered a critical factor and part of a technology system, beyond their interaction (FORLIZZI, 2018). The Service Design scope (which seeks for sustainable solutions and optimal experiences for customers in unique contexts and for any service providers involved) would be a way to go beyond UCD and UX and try to deepen and improve what is being designed today.

For Hassenzahl (2008), people perceive interactive products along two dimensions (pragmatic and hedonic), where the former requires focus on the product (utility and usability in relation to potential tasks) and the latter relates to the Self (human needs such as novelty, change, personal growth and self-expression). In this scenario, a good experience would come from satisfying human needs (hedonic), while the pragmatic dimension facilitates the potential of fulfilling the goals of the self. Therefore, the hedonic quality is central to the positive experience, while the pragmatic is indirect, only making the process easier and more likely

(HASSENZAHL, 2008). That way, an analysis of autonomous educational systems focused on pragmatic issues may be incomplete and detrimental to the human, especially in the long run.

Giacomin (2014) characterizes the main movements operating in the world of Design today: Technology Driven Design, Sustainable Design, and Human-Centered Design (HCD). Despite operating within the same environment, these would be important movements that lead to distinct outcomes. HCD differs from UCD by being less concerned with functions and more concerned with allowing many individual or cultural conceptions to unfold in seamless interfaces with technology. People (for whom the system is intended) drive its questions, ideas, and activities, rather than materials, technologies or designers' personal creative process. Thus, the HCD model consists of a series of questions and answers that span the entire spectrum, from the physical nature of people's interaction with the product or service, to the metaphysical (GIACOMIN, 2014). Thinking about Design and autonomous Edtech, one can reflect: there will be a "conflict" between Technology Driven Design and HCD? Designing autonomous and predictive tools without further questioning about possible problems and harms, is, in a way, to put technology ahead of people. And it could bring projects focusing on reduced or predetermined human issues, with small incremental improvements.

Giacomin (2014) proposes an interpretation of HCD based on a hierarchy of issues and problems that begins with the physical, the perceptual, the cognitive and interactive resources of the human body, and ends with the ultimate meanings that the product, system or service will occupy or create within the psychological, sociological and social of the individual. These possible long-term effects that may come from a massive or continuous use of these technologies - being psychological, sociological or social - would belong to the top of the HCD pyramid and should be approached as such.

People involved and impacted by these technologies must take part in the process of thinking, planning, and designing these systems. HCD, for example, has methodologies and techniques that interact with people to detect meanings, desires and needs, whether through verbal or non-verbal means. It seeks to investigate areas of the human mind not always directly accessible consciously, through participant observation and body language and facial coding analysis, among others (GIACOMIN, 2014). Design research has been migrating to Codesign, where designers get closer to their (future) users, in a "collective creativity". People whom the design process will eventually serve is now considered "experts" - thanks to their experience - and actively help idea generation and concept development (SANDERS; STAPPERS, 2008). This approach moves away from a perspective where trained researchers observe or interview passive users, whose contribution is to perform tasks or give opinions about concepts generated by others. Co-creation practiced early in development can have positive and far-reaching impact (SANDERS; STAPPERS, 2008).

Relating Codesign to Service Design, one can think that collective, creative collaboration, with a productive combination of perspectives, is necessary to understand users and customer needs, on the one hand, and technologies and processes, on the other. And, thereby, develop successful services (STEEN; MANSCHOT; DE KONING, 2011). Suppose Codesign and Service

Design can offer opportunities to increase focus on customers and users, improve systems, and foster creativity and cooperation. In that case, they are potentially suitable in "intelligent" autonomous and predictive educational systems' design. A broader, more human and participatory approach can help to avoid unwanted side effects as much as possible.

5. Conclusion

Autonomous and predictive educational technologies, being at different stages of development, are not yet fully effective and in use. This brings opportunities to discuss the topic before they can negatively impact humans. We need to think about the effects, both *a priori* and *posteriori*, that may hit social and educational systems.

To start answering these questions, perhaps one needs to approach this scenario with a cumulative UX notion: experience not only begins before the actual interaction (expectations), but continues after it, through reflections. And it is maintained over time, through episodes of use and periods of non-use, which may span for months or years (ROTO; LAW; VERMEEREN, 2011). If momentary analysis can inform about emotional responses to interface details, longer periods can reveal the eventual cumulative impact of momentary experiences (ROTO; LAW; VERMEEREN, 2011). It is possible to structure UX in terms of a life cycle or journey, through moments of use and reflection on them for longer intervals. Previous experiences influence future ones and reflecting or recounting after a usage episode can frame the anticipations of future episodes.

Sanders and Stappers (2008) consider that participation in design processes is still more focused on exploring and identifying a presumably positive future than on identifying and mitigating adverse consequences. However, they assert that both perspectives will need to be addressed in an integrated way to meet these new challenges. We need to question, evaluate, research, and work with all scenarios and possibilities in mind, especially those that may be most damaging.

This process, and discussion, will require adjustments and dialogue over time, but they are fundamental. The worst option would be not to deepen the questioning and analysis about these autonomous educational systems and their relationship with humans.

The fields of Design and Human Factors/Ergonomics presented here differ in some proposals, but, in all of them, some approaches can come close to a systemic, humanistic, and continuous handle that may be better for autonomous Edtech. Professionals from the various fields mentioned here can help to propose solutions by adopting social and behavioral science methods from a broader socio-technical perspective. They can take part in educational AI development and research, increase their influence, enhance their knowledge, and integrate methods between these fields to promote cooperation. A laborious effort, perhaps, but one that something so fundamental, such as teaching and learning, surely deserves and demands.

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