WE NEED A CUMULATIVE AND SYSTEMIC APPROACH TO HANDLE AUTONOMOUS INTELLIGENT EDUCATIONAL SYSTEMS

PRECISAMOS DE UMA ABORDAGEM CUMULATIVA E SISTÊMICA PARA LIDAR COM OS SISTEMAS EDUCACIONAIS INTELIGENTES AUTÔNOMOS

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Autonomous and intelligent solutions, based on data collection and Artificial Intelligence, increasingly permeate our daily lives, and the benefits of time, cost, and scale can already be seen. Nevertheless, what are its possible implications in a complex field such as Education? The so-called Edtech, through technologies such as Intelligent Tutoring Systems and Adaptive Platforms, evolves to become able to record, evaluate and predict the cognitive and emotional behavior of students and provide answers and personalized learning paths with little or no human participation. Many authors question 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 importance of Education for society as a whole, this article proposes a (self) critical discussion and two questions: in a human-centered approach, what are the implications for UX, Ergonomics, and Design professionals when designing and evaluating these systems and solutions? Moreover, since autonomous and predictive Education is complex and delicate, shouldn´t these people handle it through more systemic and continuous approaches?

Edtech, Inteligência Artificial, Ergodesign, UX
Nosso cotidiano é cada vez mais permeado por soluções autônomas e inteligentes baseadas em coleta de dados e Inteligência Artificial. E já se observa seus benefícios de tempo, custo e escala. Mas quais suas possíveis implicações num campo complexo como a 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 para a sociedade, este artigo propõe uma discussão (auto) crítica e duas perguntas: numa visão centrada no ser humano, quais as implicações para profissionais de UX, Ergonomia e Design ao projetar e avaliar esses sistemas e soluções? E sendo a Educação autônoma e preditiva tão complexa e delicada, essas pessoas não deveriam lidar com ela através de abordagens mais sistêmicas e contínuas?

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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). However, what is “human nature”? It is often seen narrowly in terms of perception, cognitive processes, and the ability to perform efficiently. That way, technology would be characterized as a tool to save time and do things “better”. Some question that technology can also be a source of pleasure, going beyond the performance of tasks (HASSENZAHL, 2008). That considered, 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 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 autonomously process real-time analysis of large data streams seized into their systems. This capacity would allow the personalization of learning processes and assistance of teachers, by predicting students' reactions and by performing more tedious or straightforward teaching tasks, enhancing the experience for all involved.

The question here is, what is “experience”? HF/E, Human-Computer Interaction (HCI), Human-Centered Design (HCD), and User Experience (UX) research may contribute, in correlated ways, to the discussions and approaches that these autonomous educational systems may bring. This paper shows that even though designers and ergonomists are already studying and debating intelligent 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 the challenges and changes brought by Artificial Intelligence to UX, HF/E, and Design. Next, the paper cuts to AI used in Education, especially in “intelligent” educational systems. Studies based on papers, research, and patents show that these technologies are increasingly 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, systemic evaluation to identify negative (or unfavorable) effects over the years? This paper aims to start looking for and pointing out possible ways to help answer some of these questions.

2. The challenges of Artificial Intelligence for UX, Design, and HF/E

Fast and continuous technological development allowed to new activities, media, games, and information transfer. People's lives have become increasingly dependent on Information and Communication Technologies (ICTs). New dimensions, then, arise when evaluating the quality of products, such as emotional design and pleasurable interactions (DULL et al., 2012). As Sanders and Stappers (2008) recall, we design today the future experiences of people, communities, and cultures that are now connected and informed in unimaginable ways ten years ago. Technologies powered by Big Data (a complex set of stored data that can be used for various purposes, such as predictive analytics) and Artificial Intelligence, for example, also influence the creation and design of products and systems. For Cramer and Kim (2019), one can still question whether these findings are reproducible and transferable to practice, and who would benefit from them. For the authors, it becomes increasingly challenging, even for the most experienced, to be "up to date” with the evolution and latest trends in the field, making it easy to lose sight of the past, repeat mistakes and stumble over unintended consequences. Xu (2019) recalls that the development and use of AI are decentralized and global. The cut-off line is relatively low, making it more difficult to control.

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Experimenting with the field of AI called Machine Learning can be very challenging. Systems trained with incomplete or distorted data enhance the possibility of biased "thoughts", which can amplify prejudice and inequality, spread rumors and fake news, and even cause physical harm (XU, 2019).

The primary 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 needs human judgement to define approaches, evaluate qualities, and override problems. Which brings up a question: 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, self-executing levels and adaptive abilities close to those of humans. They can operate successfully in situations that are not fully anticipatable, and the results may not be deterministic. Cramer and Kim (2019) ask: who is involved in these (non) decisions, and how are these people supported or encouraged? Product and engineering teams, editors, and data curators would need to become users demanding explanations and methods to intervene. Generalist guidelines may not translate directly to specific domains and everyday work practices. One can develop autonomous systems that perform only limited tasks in specific situations through AI. In everyday use, there will be situations that designers have never considered and which the system cannot control (XU, 2021). AI innovations such as predictive analytics, advanced decision support, next-action recommendations, robotic process automation, and systems focused on customer personalization draw attention. However, they can be costly and risky without the right skills and conditions. They often require complex AI applications, more labeled data than is immediately available, and demand changes and improvements that organizations may not be ready to meet (ZIMMERMAN et al., 2021).

There is also the documentation issue. Sometimes there is no information about an explainable AI or experiments conducted in practice. There is a lack of content about Design and UX decisions that interfere with AI feedback loops between users, communities, and systems. This situation 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).

AI, thus, is inherently a decision-making technology (VERGANTI; VENDRAMINELLI; MARCO, 2020). 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 there are many that cannot be easily quantified (CRAMER; KIM, 2019). Xu (2021) relates 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). He 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. Human-Centered Design (HCD) is an approach of developing interactive systems that seeks to make them usable and useful, focusing on users' needs and requirements; generally, it applies techniques and knowledge of Ergonomics and Usability. It seeks to increase effectiveness and efficiency, improving human well-being, user satisfaction, accessibility, and sustainability. It prevents possible adverse effects on human health, performance, and safety (ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS, 2011). UX (User Experience) results from the individual's perceptions and responses, resulting from using (or anticipating the use of) a system, product, or service. It includes all emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and achievements that occur before, during, and after use (ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS, 2011). Thus, a human-centric or UX approach should seek to raise awareness of the serious consequences of AI misuse and knowledge sharing. In this context, the intersection between UX and AI, for example, would be problematic as it deals with daily and unresolved challenges such as transparency, user control, trust, and fairness (XU, 2021). A functional AI should not just improve performance or optimize metrics. An Artificial Intelligence UX would revolve around making successful modeling results and reframing the meaning of what is considered “success” in this practice (CRAMER; KIM, 2019).

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 partnership. Considering that we now have AI with learning capabilities, humans and systems are teammates and collaborative partners. That is a dynamic cooperation between two cognitive agents with the ability to learn over time (XU, 2019). This scenario brings up a series of questions that require systematic research in areas such as HCI, Design, and HF/E. Traditional software verification methods relied on more predictable systems with no learning capability to change their behavior. It would be necessary to simulate and validate the learning and behavior of Artificial Intelligence (XU, 2019). Humans would need to curate AI flaws, that must be identified and showcased. In a Design and UX approach, humans need to find ways to mitigate them as much as possible. One concern that must be present is that any person or thing that learns, inevitably fails. In the AI context, failures are often what makes it productive (CRAMER; KIM, 2019).

Verganti, Vendraminelli and Marco (2020) ask: is AI changing the way we design? Or is it acting at a deeper level, reshaping the basic principles that inspire the act of design? It should be essential to rethink the academic formation of these fields, considering this new reality. For Xu (2021), it is necessary to bring the Human-Computer Interaction, Design, Ergonomics, and AI communities together. Designers and ergonomists need to know more about Artificial Intelligence, as well as AI developers, need to be aware of HCD concepts. It is necessary to rethink curricula and training, facilitating collaboration and favoring different capacities (XU, 2021).

The points raised here can reinforce the importance of thinking and designing AI to cause the least harm, to think about projects and processes collectively, and involve professionals from various fields, themselves users, in a way, of what they are designing. There are already initiatives such as that of Stanford and Berkeley Universities with MIT, which established the HAI (Human-Centered AI) research institute. There, it is emphasized that the frontier of AI is not only technological, but also humanistic and ethical. AI should serve to improve humans, not replace them (XU, 2019). This scenario brings questions and natural “tensions” between fields such as UX, HCD, HF/E, and AI. That makes one wonder if the present quest for automation of certain specific educational processes is not rushed and dangerous. Xu (2021) reinforces that the HCI community must recognize the potential risks of autonomous systems that center machines on decisions, instead of humans. How much is known about these systems? How to ensure that humans will have the final decision? What can be done to improve the security of these processes (XU, 2021)?

Artificial Intelligence has been used and applied in educational contexts. Research such as Roll and Wylie (2016) suggests two strands of research in the area: the evolutionary development facilitated by AI in various environments, such as learning practices and interactions with teachers in the classroom; and the study of changes in the adoption of technologies in the daily life of students and communities (FENG; LAW, 2021). Pinkwart's study (2016) points out that challenges of AI in Education include implementation, practical effects of AI systems in cross-cultural global learning settings, and issues of privacy, scalability, and system effectiveness. A field study named Artificial Intelligence in Education (AIED) integrates methods and tools from various disciplines, such as computer and information sciences, to address educational problems. One of the significant interests of AIED would be to develop intelligent problem-solving systems to facilitate teaching and learning activities (FENG; LAW, 2021).

So, given the problems, challenges and issues, and scenarios brought up here, how can Design and HF/E, within its various ramifications, approach educational AI, Machine Learning, and Big Data, without losing focus on the human being? It takes awareness and information so that potentially dangerous systems are not

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developed and launched, harming people. Technology can likely facilitate many educational processes. However, care and questioning are necessary for it to be done with balance. In this sense, it is necessary to know and problematize the scenario of Edtech's teaching processes in the coming years.

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

To contextualize the increasing adoption of intelligent technologies in educational processes, one can turn to Mendonça Neto, Vieira, and Antunes (2018), when they sought to differentiate Education and teaching:

> It is worth emphasizing the distinction established by Khôi between Education and teaching. For the author, Education is the set of processes that prepare man to play his role in society and comprises not only his intellectual development, "[…] but also his physical, moral and aesthetic formation." (op.cit., p.13). On the other hand, teaching consists of transmitting knowledge, with its vicissitudes (KNIGHT, 2009). Khôi (1967, p. 13) recognizes that this distinction is often formal and semantic, since any teaching process worthy of the name also participates in the formation of spirit and character. The author also observes that, "from the point of view of an economic analysis however, we can only work with statistically defined magnitudes, that is, teaching rather than education" (MENDONÇA NETO; VIEIRA; ANTUNES, 2018, p.151, translated by the authors).

Thus, choices made in the teaching process, for whatever reasons (pedagogical, economic, political, among others), inherently influence the human aspect. It can shape the collectivity's physical, moral, and intellectual development that forms society in the long run. These choices impact those directly involved (students, parents, teachers, coordinators) and potentially all human beings. Given the questions and doubts that still surround technologies based on AI and Big Data, much care and attention are needed when using them in educational situations. Especially 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. The information would flow differently, from company to user, allowing a person-specific solution and constantly improving the experience 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 the cognitive state during the learning process 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 databases on the subject in countries such as the US, the European Union, Canada, and Brazil - identified some 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) confirm it by reviewing 1,830 research articles on AIED between 2010 and 2019, aiming to provide "a holistic picture of the evolution of knowledge in this interdisciplinary research field". Their results showed that "Intelligent tutoring system" and other keywords such as "natural language processing," "educational data mining," and "student modeling" had high popularity throughout the documents analyzed (FENG; LAW, 2021). ITS are integrated educational tools that potentially could personalize formal Education using instruction or feedback. They are computer-based learning environments that incorporate computational models from the learning and cognitive sciences, computational linguistics, AI, mathematics, and other fields. ITS has transformed teaching, learning, and associated research (GUO et al., 2021).

> Artificial intelligence in education comes of age in systems now called “intelligent tutors,” a step beyond traditional computer-assisted instruction. Computer-assisted instruction evolves toward intelligent tutoring systems (ITSs) by passing three tests of intelligence. First, the subject matter, or domain, must be “known” to the computer system well enough for this embedded expert to draw inferences or solve problems in the domain. Second, the system must be able to deduce a learner's approximation of that knowledge. Third, the tutorial strategy or pedagogy must be intelligent in that the “instructor in the box” can implement strategies to reduce the difference between expert and student performance. At the foundation of ITSs, therefore, one finds three special kinds of knowledge and problem-solving expertise programmed in a sophisticated instructional environment (BURNS; CAPPS, 1988).

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 mainly was 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 the classroom,” but it is a trend that is already noticeable and will hopefully be in mainstream use by 2030 (VICARI, 2018).

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; AI 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 the next step in the system. 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; its translation, correction, and generation without human participation.

Table 1 – Some of the technologies being used and / or researched in the EdTech context (Based on Vicari, 2018)

Given this scenario, what are the risks of autonomously "labeling" through algorithms, people's cognitive and emotional profiles? 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. However, 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.” For the authors, Edtech should be a propeller of this posture. Is learning a product or a process? Selwyn (2011) recalls that many theories see learning as a product, where the result is “gaining knowledge” and “filling empty vessels.”
With data-based assessment, control over life no longer comes from social relationships and interactions mediated by natural languages but by algorithms and computational systems. People spontaneously think while acting much more often than one might think. Much cognition may not fit into mental models but would result from 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 in bodies and socio-material practices (cultural and physical artifacts). Cognition would be distributed between human and non-human actors (BANNELL, 2017). As Russell (2021) asks: what use is data without the prior knowledge with which it is to be combined?

AI 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, and “many of these models encode misunderstandings and biases.” They are sometimes complex to the layman, challenging to monitor, enforce, and operate under legislation that does not yet address them. They are based on probabilities, sometimes elevated to the status of certainties (O'NEIL, 2016). Finally, Artificial intelligence does not yet possess empathy. They would have to experience and understand emotions, something complex even for humans. There is a potential danger in using machines for decisions that “affect people and degrade the status and dignity of humans” (RUSSELL, 2021). 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 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 like a human does when reading or interpreting images. Autonomous systems would determine learning and action based on past predictions embedded in algorithms, leading 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, a simplification. That means that it is created through choices of what is - or is not -, important enough. Models and systems reflect goals and ideology. Values and desires influence the data collected and the 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 students' feelings about their 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 that can be used to monitor, which can impact student and staff well-being, as academic life and practice are increasingly prescribed from data-driven performance management, potentially bringing powerlessness increased anxiety.

Selwyn (2019) points out that there is a fine line between being assisted and supervised. A system that records and analyzes every conversation between students and teachers could be a practice and a performance measurement tool. Teachers could lose control and autonomy over their production, be forced to adjust to what the machines expect, or settle for what systems cannot do. This situation would make their work less worthy. If humans become computers' tools (only providing information and correcting errors), would they be able to understand in-depth how these systems work (RUSSELL, 2021)? 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 and serve to control and evaluate their performance via criteria such as the number of accesses, time spent online, and the number of tasks requested from students. By the very way they are designed, these systems would induce pedagogical practice standardization to facilitate the replacement of professionals. They may also include administrative support platforms that transfer non-pedagogical activities to teachers (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 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 likely surprise human operators even more than is already seen in automation (XU, 2021). Even if teachers remain in the classroom, is there the risk of 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 (HCI) 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). 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 (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 as "good" or "bad." Thus, a continuous and broad observation, beyond interaction and function, should not be undertaken of these people's experiences?

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

The Human Factors and Ergonomics Society (HFES) advocates using 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 consumer products 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 us that it is necessary to consider its effect on the role and behavior of humans when thinking about an ergonomic taxonomy in technology. For Hassenzahl (2008), 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 the experience, and the feeling of “good-bad” would regulate our behavior. However, do not 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 modify the current understanding of “well-being” and cognitive and system performance (DITTMAR et al., 2021). For Dull et al. (2012), when Ergonomics/Human Factors do 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 computers and products with 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 are rare in HCI for reasons of complexity and technological change. 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 when one interacts 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 do evaluate unique and remarkable “moments” and integrate momentary feelings into a later, cumulative feeling or sense?

Wouldn't the paradigmatic changes from these educational technologies require a human-centered approach that 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).

As said, Education and its development have not only a solid physical, cognitive and emotional impact on people, but they also change the social and cultural structures themselves. 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 to 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 categories of “products” to designing for people's purposes.

Similarly, Forlizzi (2018) points out that one needs to go beyond User-Centered Design (UCD) and UX and consider designing services. Almost everything made would be a service or platform designed for various stakeholders to interact. Services are distinct from products because they are systemic and designed for multiple people. Services need a broader design approach. People need to be considered a critical factor and part of a technology system beyond their interaction (FORLIZZI, 2018). The Service Design scope (which seeks sustainable solutions and optimal experiences for customers in unique contexts and 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 to focus on the product (utility and usability concerning 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). In that way, also in a UX approach, an analysis of autonomous education systems focused on pragmatic issues can be incomplete and harmful to humans, especially in the long run.

Giacomin (2014) sees three 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 essential 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. Moreover, it could bring projects focusing on reduced or predetermined human issues with minor 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-run effects from massive or continuous use of these technologies - psychological, sociological, or social - would belong to the top of the HCD pyramid and should be regarded as such.

People involved and impacted by these technologies must take part in 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 that are not always directly accessible consciously through participant observation, body language, and facial coding analysis (GIACOMIN, 2014). To Sanders and Stappers (2008), Design research has been migrating to Codesign, where designers get closer and closer to their (future) users in a “collective creativity.” People whom the design process will eventually serve are now considered "experts" - thanks to their experience - and actively help idea generation and concept development. 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 positively and profoundly impact designs (SANDERS; STAPPERS, 2008).

Relating Codesign to Service Design, one can think that collective, creative collaboration, with an effective combination of different perspectives, is necessary to understand users and customer needs, on the one hand, and technologies and processes, on the other, and thereby developing 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,

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they are potentially suitable in "intelligent" autonomous and predictive educational systems design. A broader, more human, and participatory approach can help avoid unwanted side effects as much as possible.

5. Conclusion

Dull et al. (2012) point out that although the ergonomic role of improving well-being may find support from some stakeholders, others may consider it excessive or delaying technological development. However, Hassenzahl (2008) stresses that an authentic user experience perspective aims to take the underlying needs seriously and design technologies that meet those needs. In the autonomous ITS case, perhaps the different approaches of Design and HF/E in this discussion can reinforce the importance of a systemic, continuous, cumulative approach based on the participation of the people involved.

From the stakeholders, decision makers must understand the breadth and complexity of the subject. Teachers must dimension what this could mean for their practice. Governments, parents, and students need to think about what this can mean for their personal and social upbringing. Educational institutions and developers must consider that, more than a possible delay or higher development cost, discussing these topics and developing them into practice can prevent their products from being subsequently prohibited or limited by legislation.

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

For example, in the Cognitive Ergonomics field, this would mean an iterative, interdisciplinary practice that would involve design, theory building, and experimentation with envisioned solutions. A process where prototypes are no longer primarily partial representations of the final system (oriented by the product), and would instead investigate how cognition and collaboration are shaped by the concepts incorporated in the project (DITTMAR et al., 2021). Karwowski (2012) highlighted that HF/E should drive technology, leaving a reactive design approach.

To start answering some questions raised in this paper, 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. 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 a brief analysis can inform about emotional responses to interface details, more extended 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 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. Of course, some practical questions arise: who would bear these costs? Who would define the parameters of these analyses? Would such care be an excess that would delay technological development? How can we preemptively measure or assess the effect of technologies over the long run if it depends on the unanticipated use humans make of technologies? Cramer and Kim (2019) stress that the concern about AI is creating a flurry of new frameworks and guidelines, which may bring about a crisis of accountability caused by the "fatigue of its practitioners." However, anticipating harms, including obvious ones, requires techniques grounded in skills that communicate an "effective critique" that can influence decision-makers (CRAMER; KIM, 2019). With its techniques of case studies and real-world experiences, UX, for example, could approach AI to go further in sharing these experiences.

This process and discussion will require adjustments and dialogue in the long term, but are fundamental. The worst option would be not to deepen the questioning and analysis of 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 participate in educational AI development and research, increase their influence, enhance their knowledge, and integrate processes between these fields to promote effective cooperation. A laborious effort, perhaps, but one that something so fundamental, such as teaching and learning, surely deserves and demands.

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