How Can We Design for Learning in an AI World?

Abstract

Fast improvements in computing power and Artificial Intelligence (AI) algorithms enable us to automate important decisions that shape our everyday lives, and drive workplace transformations. It is predicted that many people will find themselves unprepared to deal with high degrees of change and uncertainty, increasingly posed by AI in some sectors. A critical educational challenge involves figuring out how to support young generations to develop the capabilities that they will need to adapt to, and innovate in, a world with AI. This article argues that both educators and learners should be involved not only in learning but also in co-designing for learning in an AI world. Further, they together should explore the knowledge, goals and actions that could help people shape future AI scenarios, and learn to deal with high degrees of uncertainty. A key contribution of the paper is a re-conceptualisation of design for learning in an AI world, which explores a problem space of educational design. As part of this problem space, the paper discusses underpinning philosophies (the capability approach and value creation), a high-level pedagogy (with an emphasis on co-creation), pedagogical strategies (speculative pedagogies), and pedagogical tactics (AI scenarios). It then proposes a design framework (ACAD) to support educators and learners' discussions about design for learning in an AI world. This participatory design approach aims to sensitize people for what education may mean, for whom, and how learning with AI may look like, and it highlights the active engagement of educators and learners in co-designing a future they desire, to help shape learning and living in an AI world.

1. Introduction

UNESCO's (2020) sustainable development agenda outlines the need for action on a range of complex societal issues, including climate change, poverty and hunger. One of the main aims of education is to prepare young generations for the future, which includes learning to address these societal issues, but also learning to deal with the rapid development of technologies, and to cope with the continuous access to vast amounts of new knowledge and information. Samochowiec (2020) points out that policy and studies about 'future skills' tend to assume that the kinds of skills future generations will need are fixed, and that studies rarely address the unpredictability of the future. Many educators often struggle to align their pedagogies to the uncertainty and complexity of modern times (Zawacki-Richter et al., 2019); and policy tends to fall behind due to the speed of technological advancements. Central to this discussion on how technological disruptions are (and will continue) affecting human society is the development of artificial intelligence (AI).

AI has changed the way we go about our daily lives – it is in our smartphones, at the ATM banking machines, the Internet, and all around us – and is likely to continue to shape the future of humanity. Important decisions are automatically or semi-automatically made, based on the outputs of AI algorithms, and these are already affecting jobs and incomes, and disrupting the workforce (Samochowiec, 2020). In fact, no one knows the extent to

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which jobs and professional careers will be affected. Most projections on the proportion of jobs susceptible to automation vary significantly, from 9% to 96% (Arnts et al., 2016; Manyika et al., 2017; Muro et al., 2019; Dellot et al., 2020). From a historical perspective, fears related to job loss due to automation are not new (David, 2015). However, AI is now challenging assumptions about what capabilities are intrinsically human, such as creativity and complex problem solving (Iansiti & Lakhani, 2020). Further, even though new jobs most likely will emerge to compensate for job losses, the very rapid developmental cycles of AI are also accelerating the pace in which humans need develop their relevant new capabilities which are not yet known (Harari, 2018). Some people are already being forced to re-invent themselves to stay current in the job market, and they will likely need to do so at greater speed and more than once in their lifetimes (Nissim & Simon, 2021), which further contributes to uncertainty.

Currently, despite the impact of AI in our lives, most people do not fully understand AI, the decisions that can be made by machine algorithms, or the role people play when interacting with AI. Importantly, AI has significant ethical implications, which are being increasingly highlighted as part of a much-needed conversation. As society moves forward, it is crucial that people come to understand how their present situation may impact the multiple future possibilities, and there is a pressing need to support educators and learners to figure out how to create the best possible future, as urged by UNESCO's initiative the *Futures of Education: Learning to Become* (2021).

The main contribution of this article is the re-conceptualization of educational design in an AI world, by exploring a problem space of educational design. We primarily focus on design for learning, with a grounding on humanistic approaches, human agency, co-creation and wellbeing. In order to delineate the problem space of design for learning in an AI world, we first introduce recent developments connected to learning in an AI world.

2. Learning in an AI world

There are a number of critical questions related to Education and AI: What should every child know about AI? How can we support learning in AI mediated contexts? What are our core values and how can these be reflected in an AI world? (Touretzky et al., 2019). The uncertainty regarding the speed and depth in the development of AI and its potential impact on society makes such questions hard to answer.

In formal educational contexts, such as schools and universities, there has been an initial proliferation of AI applications, including learning analytics systems and algorithm-based decision-making, to support learning and teaching (Agus & Samuri, 2018). These innovations offer promising benefits, such as the early identification of challenges students may be facing (Arnold et al., 2012), scaffolding self-regulated learning skills (Fan et al., 2021) and providing real-time support (Lucas et al., 2021; Martinez-Maldonado et al., 2021). However, many educators are still unsure about how AI may impact teaching and learning (Zawacki-Richter et al. 2019). It is also becoming evident that AI can make some issues even more pronounced, for example, by measuring the performance of teachers for punitive purposes (Selwyn & Gasevic, 2020), profiling students (Selwyn, 2019), and rolling out biased algorithms that can recommend misleading actions (Buolamwini & Gebru, 2018). In fact,

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some authors are starting to question whether AI innovations in education may cultivate certain world views that risk perpetuating colonialist ways of thinking (Williansom & Eynon, 2020). Zawacki-Richter et al. (2019) argue that there is a lack of critical reflection about the challenges and risks of AI and highlight the need to strengthen ethical and AI-related education.

The power and danger of AI have prompted policy responses globally. Indeed, it is noted that existing AI policy initiatives have not addressed AI capacity building adequately, including learning about AI (i.e., AI literacy and understanding what AI is), learning with AI (i.e., implementing AI in education), and learning for human-AI collaboration (i.e., living in a world that is increasingly integrated with AI) (Miao et al., 2021). In fact, debates around AI and its impact on society have focused largely on the fear of job replacements, while the implications for learning and skills development received comparatively little attention (Luckin et al., 2016). UNESCO (2019, 2020, 2021) has also made a number of recommendations to harness the power of AI and achieve the global sustainable goal of quality education. In particular, UNESCO's recommendations call for a 'humanistic approach' as the overarching principle for AI in education, which includes protecting human rights, equipping people with skills needed for sustainable development and for human-machine collaboration in life, learning, and work, as well as fostering human values that are needed to develop and apply AI. UNESCO's key recommendations highlight that the use of AI should:

- Protect students' agency and social wellbeing, and
- Empower teachers in their work of facilitating co-creation of knowledge, human interaction, higher-order thinking, and human values.

Pedagogical practices that emphasize human skills (creativity, complex problem solving, critical thinking, and collaboration) are needed for supporting one's ability to communicate and collaborate with AI tools in life, learning, and work. In response to this humanistic view, we suggest the adoption of a capability approach (Sen, 1985, 1992, 1999). Humanistic approaches, agency, co-creation and wellbeing are included in the problem space of designing for learning in an AI world. In the next section, we introduce Goodyear's (2005) conceptualization of the problem space of educational design to ground our discussion of design for learning in an AI world.

3. Defining the problem space of design for learning

Goodyear's (2005) problem space of educational design includes a discussion of a pedagogical framework and an educational setting. Goodyear's original account conceives the pedagogical framework as composed by four layers (Figure 1). At the highest level is the 'philosophy' layer – which acknowledges how we think people learn, or our understanding of the nature of knowledge. The second layer, 'high level pedagogy', is a more concrete instantiation of the above philosophical assumptions, and does not contain specific prescriptions for actions. It is in the third and fourth layers that actions would be accounted for – 'pedagogical strategy' refers to a broader plan, while 'pedagogical tactics' are a more fine-grained version of strategies. In Goodyear's problem space, the 'educational setting' represents the 'real world' where learning activities take place.

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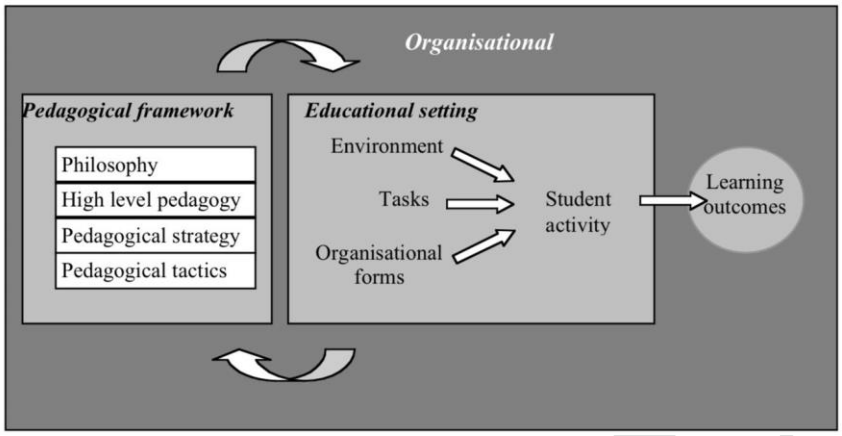
Figure 1: The problem space (Goodyear, 2005)



In alignment with Goodyear's (2005) work, we conceptualize the problem space as including a pedagogical framework and a learning situation (Figure 2). Here, we adopt a broad notion of the 'educational setting' and call it 'learning situation' to acknowledge other forms of learning beyond formal education. In its essence, our proposed re-conceptualisation of the problem space of educational design acknowledges that participation and co-creation are core to design for learning in an AI world.

In the next few sections of this article, we will discuss the main elements of the design for learning space that include:

- An underpinning philosophy – which foregrounds both the capability approach and value creation framework through principles that connect agency, inclusion, and co-creation (section 4);
- A high-level pedagogy – which highlights co-creation as an approach to collaborative knowledge building and learning for uncertain futures (section 4);
- Pedagogical strategies – drawing on speculative methods to promote human agency in an AI world, we discuss the usefulness of these methods as pedagogical tools (section 5);
- Pedagogical tactics – which is about the potential for using scenario planning methods to re-imagine a world with AI and stimulate design for learning ideas (section 5); and
- A design framework – focusing on the Activity-Centred Analysis and Design (ACAD) framework to identify relationships between different dimensions of design, and consider how multiple elements may come together in support of learning activity, such as tools (digital and material), tasks, ideas, and people (section 6).

Figure 2: Re-conceptualizing a problem space for educational design in a world of AI

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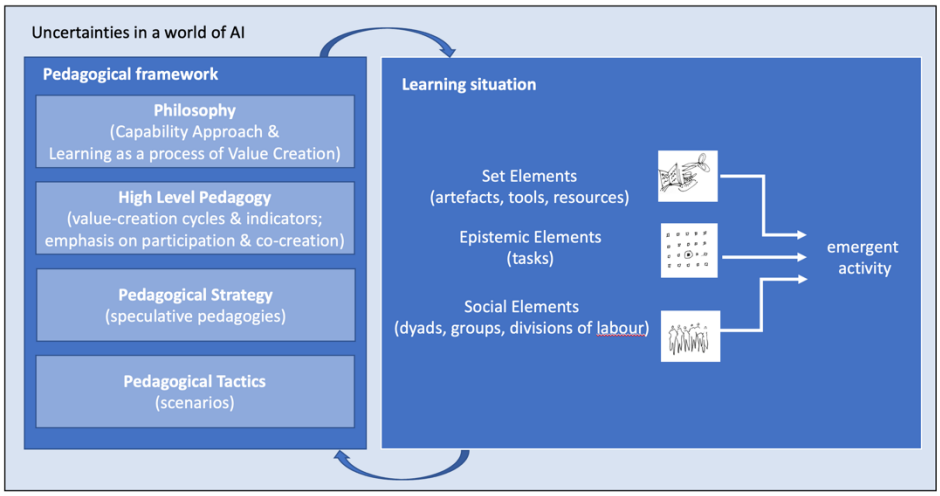

The next section discusses two elements of the pedagogical framework. We start with a description of an underpinning philosophy based on ideas of a capability approach (Sen, 1985, 1992, 1999) and learning as a process of value creation. We then consider a high-level pedagogy drawing on the value creation cycles and indicators (Wenger et al., 2011).

4. High-level philosophy and pedagogy: The capability approach and value creation

To address the high levels of uncertainty and disempowerment of people, design for learning should be underpinned by humanistic approaches that focus on empowering learners (UNESCO, 2019). As part of our conceptualization of the problem space we included the capability approach as the underpinning philosophy, and we also considered that learning should be seen as a process of value creation (Figure 2). In educational contexts, collaborative approaches are often used to facilitate joint meaning-making and co-creation among various stakeholders. To successfully co-create education futures in an AI world, educators and learners would need a safe space, where educators might bring their professional expertise and learners their unique experiences and desires, to jointly integrate ideas and agree on the aspired values and teaching and learning outcomes. A sense of agency is essential to co-creation, as people need to feel empowered to make decisions towards personal goals, which is part of the key capabilities required for an individual's participation in designing for learning in the context of an unpredictable AI future. The capability approach brings a humanistic approach, with a focus on agency and wellbeing.

Poquet and De Laat (2021) have argued that settings for learning and development require that individuals make choices about what they value and what they like to pursue. Especially in the context of lifelong learning these choices are very personal, influential and existential. Many have argued (e.g., Boyadjeva & Ilieva-Trichkova, 2018; Rubenson, 2019) that educational approaches to lifelong learning need to extend learning and education to include human development, wellbeing and equity through a 'capability approach'. The capability approach, as originally conceived by Amartya Sen, emphasizes human development rather than human capital, focusing on values of individuals and the structural constraints that may prevent people from achieving these values (Sen, 1985, 1992, 1999). As such, capability is connected to agency and to one's ability to follow their own

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aspirations. It is about being 'free to do and achieve in pursuit of whatever goals and values he or she regards as important' (Sen, 1985, p. 203).

Some of the core concepts related to the capability approach include *capability*, *functioning, freedom, conversion factors,* and *agency.* Essentially, the capability approach is about what people can do within the constraints of what they have, and towards their moral right of wellbeing. Important to our discussion in this article, is the notion of *capability* and how it acknowledges that people have individual *freedom* within a set of opportunities that are available to them, whereas *functioning* refers to resources, activities, or attitudes that individuals recognize as important to the achievement of their goals (Comim et al., 2008). In sum, a focus on capabilities emphasizes both freedom and opportunity. The capability approach envisions the empowerment of learners and educators so that they can find effective ways to support the development of knowledge, goals and actions that would be necessary to deal with uncertainty, and the upcoming change in potential future scenarios of a world with AI (Samochowiec, 2020).

Related to the capability approach is the concept of learning as a process of value creation. The *value creation framework* developed by Wenger, Trayner and De Laat (2011) focuses on the value that people and networks create when they engage in social learning activities. Human experiences are constantly evolving, and over time people and networks create stories. It is in the context of these stories that one can appreciate what 'learning' is taking place and what value is being created. Value creation stories are accounts of what happened, they represent aspirations for what people are trying to achieve. These stories are often rich, on-going and situated in daily activity. However powerful these stories may be, there is a paradox when it comes to making it a real asset within networks, communities of practice and/or organisations (De Laat, 2012): implicit spontaneous learning activities are often mostly invisible to everyone not directly involved. Indeed, the learners themselves might not even be aware that they are learning. As a consequence, informal learning goes undetected, and is therefore hard to assess, manage and value (Wenger et al., 2011).

There are five cycles in the value creation framework. The first cycle places emphasis on the *immediate value* as experienced by the participants. For example, having an inspiring meeting with great discussions and insights, holds direct value in itself. The second cycle refers to *potential value*. This value has not yet been realized, but holds promise in the context of the learning experiences that take place in networks and communities. For example, an experience may be shared on how to respond to a certain situation. This situation may never occur, but it is reassuring to know what to do. Another example could be about resources being shared within a network. These resources may prove useful to members later on. *Applied value,* the third cycle, refers to changes in practice. What is the impact of participation on the way people do things? A person may decide to implement a certain idea that was first presented or suggested by other members of the network. When looking at applied value, one is trying to identify how practices have changed in the process of leveraging knowledge that is shared in a network or community. The fourth cycle, *realized value*, is about understanding how performance has been improved, for example, because of change in practice. What evidence can be gathered to document what has been achieved as a result of implementing change or applying a new practice? The fifth and final cycle is about *reframing value* or redefining success. Sometimes the outcome of learning

entails a complete transformation of how people see and understand things, as well as redefining how success is measured or achieved. This could include reframing strategies, goals, as well as values. It can also mean transforming or leaving behind existing structures in favor of a new framework or approach.

The value creation framework provides a way of making undetected learning activity more explicit, using value creation cycles and indicators to help paint a picture of the value that is being created based on available data embedded in, or associated with, people's stories. As such, the value creation framework helps people reflect on their aspirations and their engagement in activities, which in turn may also help people achieve them. It foregrounds a view of learning where people would be dealing with change as a process of value creation, which fits well in the context of designing for learning and AI, and dealing with high levels of uncertainty.

Within the problem space of educational design, we foresee the capability approach as providing a humanist perspective where human development, wellbeing and equity are core underlying assumptions for how people learn in a world of AI (Figure 2). We also regard co-creation processes as an inherent part of a value-based design approach. We envisage the value creation framework supporting discussions about what people value and the world they want to live in, what education could be like, and how learning with and about AI could be realized. The unpredictability of the future requires that we learn how to deal with change, and in so doing, we derive personal and collective values from this learning process. Pedagogies that support value-based learning and future-oriented discussions are important for making these high-level ideas actionable. We discuss them next.

5. Pedagogical strategies and tactics: Pedagogies for unknown futures

This section moves to the next two elements of the pedagogical framework in the problem space of educational design (Figure 2) and discusses pedagogical strategies and tactics — a set of methods that can help us embrace the uncertainty of learning and living in the world of AI. How could we empower and prepare students for a world which does not exist yet, when we only know that this world will be permeated with AI? In the areas of social learning and transformation, we saw the emergence of various future-oriented radical design and action learning methods, such as social dreaming (Dunne & Rabby, 2013; Long & Manley, 2019). These participatory methods aim to build collective capacities of communities to think through probable, plausible, possible, and preferable futures that people want, and build a foundation for actions that could lead to these futures. They offer 'methodological playgrounds' for engaging people in collective thinking about their futures and for changing their personal relationship to them. Dunne and Rabby (2013) argue that the primary purpose of such speculative methods is to "create spaces for discussion and debate about alternative ways of being and to inspire and encourage people's imaginations to flow freely" (Dunne & Rabby, 2013, p. 1). The assumption is that joint imaginative speculations allow people to create a better understanding of what kinds of futures they want and do not want. This increases the likelihood of follow-up actions towards the preferred futures, preventing those that are undesirable.

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These methods also have been used as pedagogical tools to empower learners to co-create visions of the future world they want to live in (Gonçalves, 2016). Radical design and action methods aspire to democratize knowledge and empower learners to take hold of their own futures. Therefore, they often focus on socio-emotional aspects of shared imagination and learning, breaking connections from the conventional ways of creating knowledge that often have origins in Western intellectual cultures. As Dunne and Raby (2013) claim:

> "Being involved with science and technology and working with many technology companies, we regularly encounter thinking about futures, especially about 'The Future'. Usually, it is concerned with predicting or forecasting the future, sometimes it is about new trends and identifying weak signals that can be extrapolated into the near future, but it is always about trying to pin the future down. This is something we are absolutely not interested in; when it comes to technology, future predictions have been proven wrong again and again. In our view, it is a pointless activity. What we are interested in, though, is the idea of possible futures and using them as tools to better understand the present and to discuss the kind of future people want, and of course, ones people do not want." (Dunne & Raby, 2013, p. 2).

Educational decision-makers and researchers have been trying to address the question of possible futures by engaging in forward-thinking studies. Historically, among the best known such studies have been the OECD's studies, including *What schools for the future* (2001), and later *Think scenarios, rethink education* (2006), where educational experts and policymakers employed future thinking methodologies to conduct analyses and develop scenarios of tomorrow's education (van Notten, 2006). Many different types of scenarios can be developed, and the core idea of the scenario development methodology is to engage policymakers in a rigorous forward-thinking process about possible futures by integrating current knowledge about education and firmly focusing on the trends in the wider environment, such as developments of AI. These constructed scenarios are "consistent and coherent descriptions of alternative hypothetical futures that reflect different perspectives on past, present, and future developments" (van Notten, 2005, p. 70). They are shared knowledge artefacts that provide the grounding for discussing possible policy decisions and planning actions.

Over the last 20 years, there has been a significant proliferation of future studies and forward-thinking methodologies for doing such studies, including scenario development, Delphi and horizon scanning methods (Glenn & Gordon, 2009). These methods have been extensively applied in education, in particular for reflecting on and envisioning how technological developments might shape its futures. For example, for some years, EDUCAUSE has been using horizon-scanning methods to analyze weak signals in educational technology and emerging trends and how they may shape education (e.g., Pelletier et al., 2020). These methods, differently from social dreaming methods, emphasize the importance of expert knowledge and methodological rigor. For example, a recent horizon-scanning report describes the methodology as follows:

> "The Horizon Report methodology is grounded in the perspectives and knowledge of an *expert panel of practitioners and thought leaders* from around the world who represent the higher education, teaching and learning, and technology

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> industries….Following the Delphi process, our expert panelists were tasked with responding to and discussing a series of open-ended prompts, as well as participating in subsequent rounds of consensus voting (see sidebar "Panel Questions"), all focused on identifying the trends, technologies, and practices that will be most important for shaping the future of postsecondary teaching and learning." (Pelletier et al., 2020, pp. 47-48, our emphasis).

Similar foresight methods have been used in rethinking future skills and other kinds of future-oriented research (Kirschner & Stoyanov, 2020). Futures methods are broadly used nowadays in policy planning and decision-making across many domains and include a broad range of tools, such as the Delphi method, horizon scanning, scenario planning, visioning, and others (DPMC, 2021; GO-Science, 2017). These futures techniques primarily are epistemic tools for conducting analysis, engaging in structured sense-making and reaching consensus about envisioned futures. These tools are flexibly adapted to diverse contexts, problems and purposes.

Radical design and action learning methods, such as social dreaming, have been primarily created for democratizing knowledge and engaging vulnerable and marginalized communities in re-imagining and transforming their futures. Futures foresights methods have been developed as tools for experts for conducting rigorous analyses and creating joint knowledge artefacts that inform decision making. The combination of these two approaches are powerful pedagogical tools for engaging students in rigorous data collection, analysis, joint dialogue and visioning of their own futures. They empower learners by equipping them with methodological tools and agency to think rigorously and systemically about their futures, including the role of AI. Such methods are a critical part of the methodological toolbox for students who likely will face increasingly more 'wicked' challenges and uncertainty in their futures (Goodyear & Markauskaite, 2017, 2019; Markauskaite, 2020).

For example, for several years, we have been using a horizon-scanning method as a pedagogical framework in postgraduate courses on learning technology research frontiers. In these courses, students (similarly to experts) research emerging technologies, trends in wider context, engage in a joint student-led expert dialogue and create horizon reports of their chosen educational innovations. One of such courses was created using a student-led participatory design (Ripley et al., 2021). Similarly, in one course co-taught with industry partners from the global recruitment company Randstad, interdisciplinary undergraduate students' teams used scenario development methods to construct the scenarios of future work, including how this work could be affected by AI (Randstad, 2018). These students took the role of experts, as they conducted rigorous analyses of the current situation and considered trends in the field and broader context, surveyed, and interviewed stakeholders, and created utopian and dystopian scenarios of possible futures of work.

The created scenarios are also valuable knowledge objects for those who work in the industry and academia, and make decisions:

> "For industry, they [scenarios] give an insight into what kinds of future work models our graduates will be willing to adopt and in what kinds of workplace cultures they will want to work. For academia, they give an insight into what kind of future world

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> our graduates want to live in, indeed what kind of world they want to co-create." (Randstad, 2018).

To illustrate this, we could use a similar example of AI scenarios, created by Samochowiec (2020). The author suggests four possible futures, with each problematizing how AI could affect the future of education, including: collapse, gig economy precariat, net zero and fully automated AI luxury. In the *collapse* scenario, there is low social order, scarcity and restriction of freedom, a scenario that is characterized by a lack of access to basic needs such as water, food and healthcare, and which would likely challenge society and perhaps require that people develop knowledge and skills to survive, but also to adapt to or fight this grim outlook. In the *gig economy precariat*, machines take work over current middle-class jobs from humans, but only a small elite would be living beyond the poverty line. This scenario would, for example, call for knowledge and skills on how to quickly re-adapt to the job market. *Net zero* is a scenario of abundance, where most people have access to what they need, but this may require willingness to follow rules and self-restriction, which would need to be accepted and agreed upon by all members of society – collaboration and negotiation skills would likely play an important role. The last scenario is a *fully automated AI luxury*, where machines take work over from humans, and everyone enjoys the fruit of this work, which would perhaps require motivation and self-purpose.

Attempts to predict the future are risky and rarely successful, and these scenarios should not be seen as real straight predictions. Rather, they are visions of more desirable and less desirable futures created by people. There are many other potential scenarios that can be devised. But in an educational setting, the use of scenarios may offer a point of departure for reflection and discussion of positive and negative elements in future scenarios, and how we might engage with different potential challenges ahead. As such, co-creation of future scenarios can be used as pedagogical tactics to promote students' robust discussions, imagination and thinking about their futures.

Having discussed core ideas related to the four layers of the pedagogical framework in the problem space of educational design in an AI world (left of Figure 2), we now turn to a design framework which allows us to bring together and account for multiple elements in a learning situation (right of Figure 2).

5. A framework for designing for learning: The multiple elements in a learning situation

This section focuses on the learning situation, and how to frame design discussions that involve multiple elements, and as part of designing for learning in a AI world (Figure 2). We do not know what lies ahead, and yet we need to collectively figure out what is the future we would like to have ahead of us. We need to understand how we can collectively take meaningful actions to contribute to that future. In this section, we suggest that a design framework will help break down the complexity of design for learning, and allow educators and learners to reflect on part-whole relationships, that is, to consider how each design element (part) may contribute to form a specific assemblage of elements (whole), and how this assemblage in turn, influences learning activity.

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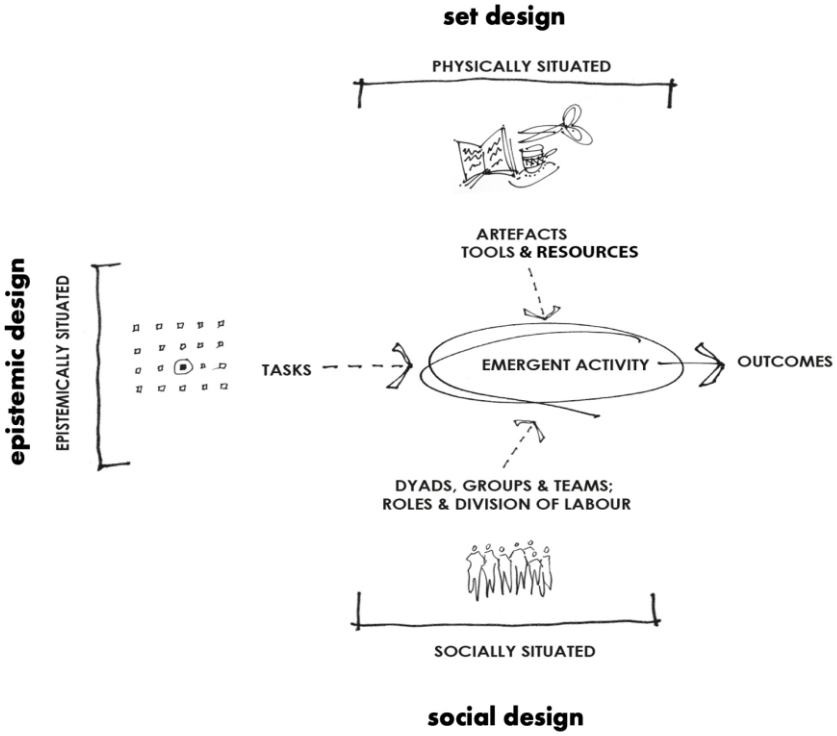
The Activity-Centred Analysis and Design framework (ACAD) (Goodyear & Carvalho, 2014; Goodyear et al., 2021) offers both theoretical and applied lenses that can help support designing for effective learning experiences. ACAD acknowledges that learning activity is epistemically, physically and socially situated, and therefore shaped by (i) proposed learning tasks or epistemic design, (ii) physical and digital tools available to learners or set design, and (iii) specific social arrangements planned in advance or social design. Learning activity lies at the heart of the framework and it is understood as an emergent phenomenon (Figure 3). The epistemic, set and social dimensions of design imply that there are choices to be made – about the tasks, tools and social arrangements of a learning situation – and these are often made by an educator (e.g., a teacher, a lecturer), resulting in an assemblage of elements. At 'learntime', when learners interact with these elements, the assemblage becomes enmeshed into the emergent learning activity. Overall, ACAD foregrounds that learners' interaction with this assemblage of elements cannot be entirely predicted in advance – as learners have agency to co-create what has been proposed. But activity is influenced by the designable components, which nudge learners into certain directions.

Figure 3: ACAD framework (adapted from Goodyear & Carvalho, 2014, p.59)



Yeoman (2015) has combined the analytical concepts from the ACAD framework (Goodyear & Carvalho, 2014) with Goodyear's (1999, 2005) earlier notions of pedagogical frameworks (Figure 1), and Alexander's et al. (1977) research on design patterns and pattern language. Yeoman (2015) suggested the use of the ACAD wireframe to map (via a grid) in a single view (Figure 4), where the multiple designable elements from ACAD are laid out at different levels of granularity – micro, meso, and macro. Drawing on the ACAD framework, the wireframe, and design anthropology (Gunn et al., 2013), Yeoman and Carvalho (2019) created the ACAD Toolkit, which consists of a cards-based method, task scaffolds, learning scenarios, and images, which are used to facilitate theoretically informed educational design discussions. As such, the toolkit has been used to support educational design teams by

scaffolding processes of *knowledge sharing* and *knowledge integration* (McDonnell, 2009), often used as conversational prompts to encourage negotiation of shared meaning, with respect to valued forms of learning activity and the designable elements that can come together in support of these (Yeoman & Carvalho, 2019; Goodyear et al., 2021)

Figure 4: ACAD wireframe (Goodyear, Carvalho & Yeoman, 2021, p.457)

Philosophy	**SET DESIGN** *Learning is…*	**EPISTEMIC DESIGN** *Learning is…*	**SOCIAL DESIGN** *Learning is…*
MACRO *The global Level I patterns*	***Buildings & technology*** *e.g. digital and physical infrastructure*	***Stakeholder values*** *e.g. forms of knowledge production and sharing*	***Organisational structures*** *e.g. hierarchy, matrix, horizontal or networked*
MESO *The local Level II patterns*	***Allocation/use of space & technology*** *e.g. provision & access*	***Curriculum*** *e.g. units of study, programs and degrees*	***Community*** *e.g. faculty, discipline, cohort or clubs*
MICRO *The detail Level III patterns*	***Artifacts, tools & resources*** *e.g. clocks, BYOD & furnishings*	***Selection, sequence & pace*** *e.g. content and timing of tasks*	***Roles & divisions of labour*** *e.g. facilitator, groups & scripts*

Using a design framework and toolkit such as ACAD (Goodyear et al., 2021) in combination with the value creation framework (Wenger et al., 2011) may help support rich discussions between educators and learners on how to design for learning in an AI world, for example whilst creating futures scenarios or whilst considering the scenarios for the future of AI created by others (Samochowiec, 2020). ACAD can help educators and learners engage in co-design activity, and guide design conversations that would account for different elements of a learning situation, through the design dimensions (set, social, epistemic). Epistemic design, for example, may consider the types of learning tasks and ways of knowing likely to be part of the future, such as creating AI scenarios or embracing other combinations of speculative and forward thinking methods. This may include learning about AI, but also learning with AI and how AI might support learning processes in ways that do not continuously replicate colonialist ways of thinking (Williansom & Eynon, 2020), and instead provide opportunities to all. These discussions can also be framed at different levels of granularity (micro, meso and macro). And include questions about what elements would be at play in the immediate surroundings of a learning situation involving AI (micro), or what institutional rules may need to be considered (if any) in different future AI scenarios (meso) and what policies may support future education practices that involve AI (macro). The underlying philosophy of such design approach includes the humanistic characteristics of the capability approach (Sen, 1985, 1992, 1999) where educators and learners can be guided by principles that connect human agency, inclusion, and co-creation, but also discuss other principles and values that may underpin their visions for the future, such as considering AI in relation to its impact on broader planetary ecosystems.

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We do not know how future learning environments will be and as we re-imagine how traditional formal classroom settings in schools and universities are likely to change even further (set design), we need to acknowledge that AI is constantly evolving. For example, learning analytics may provide real time and personalized feedback, and help both educators and learners best work with that feedback to deepen their learning experiences. We believe physical learning spaces are likely to still be important for future learning environments with AI – physical spaces provide opportunities for co-presence of humans, but new future settings may challenge strict rules surrounding the regularity of physical encounters, for example, as a Monday to Friday type of event, as it is current set in our school systems. As educators and learners engage in discussions about learning in the world of AI, considering the tools, resources and the complexity of emerging technologies (set design), they will also need to acknowledge the significance of being present with other humans (social design), in addition to discussing the role of algorithms in education.

6. Concluding remarks

Williamson and Eynon (2020) have called for the use of more participatory approaches in education, or approaches that can simultaneously enable the development of insights and changes in practice. Similarly, within the context of AI in education, we call for co-creation within society, for a view of education that involves active participation by both students and educators in discussions about learning, in learning networks and communities.

In tackling the unpredictability of the future, we re-conceptualize the problem space of educational design in an AI world, where we would like to see educators and learners deeply reflecting on the role of AI and the design structures that will shape learning activity. These ideas are embedded in our thinking about all the elements of the pedagogical framework and learning situation (Figure 2). The capability approach brings the underlying humanistic principles to underpin design in a world of AI – principles that emphasize the importance of people's agency, inclusion, and co-creation (philosophy). The value creation framework offers a way to further conceptualize learning activity within five cycles (high-level pedagogy), allowing educators and learners to adopt a holistic approach to design for learning, one that considers the immediate value, potential value, applied value, realized value and the reframing of values at stake. In addition, speculative and forward-thinking methods (pedagogical strategies), based for example on future scenarios, can be used to situate design discussions, helping educators and learners consider potential challenges ahead (pedagogical tactics). Finally, ACAD can be used to frame co-design discussions, where educators and learners explore the role of various elements, to consider their influence on emergent learning activity within multiple scenarios. ACAD can also help educators and learners search for alignment or dissonance across different design dimensions and at different levels of granularity. Altogether these analytical tools and design approaches can facilitate complex conversations about the knowledge, goals and actions that we will all need to take, in order to embrace flexibly and address the uncertainty of a future with AI. They can also inform discussions about how learning environments could look like in the future, as educators and learners work together to reimagine and co-create scenarios that are aligned with their values.

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When designing for unpredictable learning futures in an AI world, we need to recognize that humans are likely to be teaming up with AI in multiple different learning situations. Thus, as educators and learners engage in design for learning, they will not only need to plan for interactions between humans (e.g., students and students or educators and students), but bots are also likely to be playing a role in future learning environments. As such, designers will likely need to consider social structures or arrangements to facilitate and foster smooth interactions between both humans and AI. Many changes may be at stake, including the use of learning groupings that rely on age, towards accommodating environments where young and old might learn together and teach each other about different elements of living and working with AI.

To conclude, to cope with dynamisms and complexities of AI developments, we need to adopt humanistic participatory design approaches, whilst drawing on future-oriented methods and frameworks that support complex educational design conversations, and in so doing, we may contribute to empowering educators and learners to co-create the best possible future. What education will mean and how it will look like, are some of the key questions that we all need to engage with right now, as we consider the potential challenges associated with designing for learning and the unpredictable futures of living, working and learning with AI.

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