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REVIEW ARTICLE

# Agency in Educational Technology: Interdisciplinary Perspectives and Implications for Learning Design

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## Abstract

Advancing learners' agency is a key educational goal. The advent of personalized EdTech, which automatically tailor learning environments to individual learners, gives renewed relevance to the topic. EdTech researchers and practitioners are confronted with the same basic question: What is the right amount of agency to give to learners during their interactions with EdTech? This question is even more relevant for younger learners. Our aim in this paper is twofold: First, we outline and synthesize the ways in which agency is conceptualized in three key learning disciplines (philosophy, education, and psychology). We show that there are different types and levels of agency and various prerequisites for the effective exercise of agency and that these undergo developmental change. Second, we provide guiding principles for how agency can be designed for in EdTech for children. We propose an agency personalization loop in which the level of agency provided by the EdTech is assigned in an adaptive manner to strike a balance between allowing children to freely choose learning content and assigning optimal content to them. Finally, we highlight some examples from practice.

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## Introduction

Agency has been proposed as the key component of human identity and has attracted considerable research attention in the last decade, especially among scholars interested in the impact of artificial intelligence (AI) and studies of human behavior (e.g., Kahneman, 2003; Bittencourt, Cukurova, Muldner, Luckin, & Millán, 2020). Most generally, being an agent involves "to influence intentionally one's functioning and life circumstances" (Bandura, 2006, p. 164). Yet, the precise definition and operationalization of agency differs across disciplines. Various related terms are used to position and describe the construct (e.g., choice, autonomy, sense of control, self-regulation, empowerment), and diverse methodologies are used to measure its impact on behavior (e.g., observational studies, multimodal trace measurement, questionnaires, and experiments). For educational scientists, learner agency is reflected in children's active involvement in educational activities, which is thought to be a fundamental ingredient in learning (Dunlop, 2003). For philosophers, agency, in the form of subjectification, or freedom to act, constitutes a vital counterpart to socialization (Biesta, 2020). Researchers in psychology refer to people's agency beliefs or feelings and see them as foundational to intentional behavior (Bandura, 2006). Despite these different operationalizations of agency, however, scientists across disciplines recognize agency as a unique human quality that develops across childhood and adolescence and that should be fostered through education (see Duraiappah, van Atteveldt et al., 2022).

As technologies gain more data and intelligence, a new era of human-AI interaction is emerging, affording new meanings to the question of agency. More specifically, educational technologies (EdTech for short) increasingly use data-driven algorithms to adapt and automatically personalize content to individual learners. This provides EdTech designers with a challenge: how to deliver "optimal" content without sacrificing learners' agency? Teachers and educators face a similar challenge, as they need to learn how to adapt their practice in light of EdTech that impacts how children can express their agency in classrooms.

As outlined in the next section, supporting children's agency should be a priority in EdTech development and use, but the literature is surprisingly quiet about the ways in which agency could be conceptualized, measured, and implemented in EdTech design and use. We address this gap with a human-centric perspective on agency.

### The Importance of Agency in EdTech for Children

EdTech include apps, learning platforms, educational games, and other types of software that are part of the wider children's media landscape. In accordance with the definition of EdTech provided by Escueta et al. (2017), in this paper, we focus

on technology that is designed and used with a learning intention in mind. Examples include big EdTech players such as the Epic! subscription library of children's digital books or the ClassDojo web-based learning platform with a digital universe of activities as well as individual apps such as the Book Creator app for story-making. EdTech are of significant commercial value (estimated at USD 106.04 billion in 2021 globally, Grand View Research, 2021) and are a key focus of post-pandemic educational reforms worldwide (Cone et al. 2021). Given the steadily increasing EdTech use in global education, it is of considerable research and practical interest to develop educational technologies that support children's development and learning (Pérez-Sanagustín et al., 2017; Williamson et al., 2020).

In the past twenty-five years, EdTech development has been directed towards improving learning platforms, apps, and e-books that personalize learning content to the needs of individual learners (Van Schoors, Elen, Raes, & Depaepe, 2021). EdTech that adapt to the user in the course of learning draw on intelligent tutoring systems or adaptive learning technologies (Walkington, 2013) to automate the interaction between the learner and the digital content (Aleven et al. 2016). Such personalized EdTech are of most acute interest to the question of agency, given that these systems automate choices and control what learners see on their screens, as opposed to allowing learners to self-regulate their learning (see the "Psychology perspective" section for a brief treatment of the relation between self-regulated learning and agency). Intuitively, we can understand that agency given to children in EdTech solutions differs depending on the level of personalization and automation. For example, with some EdTech, such as the Lexia Reading Core5® reading software, children have very few choices as they are automatically provided with texts and games based on their progress on previous activities, linguistic competence and reading ability. With other types of EdTech, such as the Our Story App developed by The Open University, children have many more choices in stories they create and share, in that they can add their own texts, images, or audio-recordings in any sequence, length, or combination of texts and images.

The design of EdTech and with it the extent of user choices and extent of involvement varies across various apps and platforms, which raises the need for agreeing on some parameters or criteria to evaluate the extent and the way in which children's agency is granted or supported by EdTech. Leading evaluation rubrics of EdTech draw on learning theories to specify the learning conditions and design features for specific subject areas, such as literacy, mathematic learning, or learning more broadly (e.g., Cherner & Lee, 2014; Callaghan & Reich, 2018). Examples include Hirsh-Pasek et al.'s (2015) criteria for evaluating educational apps or the six criteria of reading quality for rating the educational quality of children's e-books developed by Kucirkova et al. (2017). These and other existing rubrics (e.g., Papadikis et al., 2018) define the learning conditions under which children using EdTech advance their knowledge and understanding, including safety of EdTech or interaction design that encourages active engaged learning (Zosh, Golinkoff, Hirsh-Pasek, 2017). Despite the high importance of agency for learning, however, the level of agency provided by various EdTech has so far not been considered in previous evaluation rubrics and evidence-based guides, which we believe is a significant gap.

### Aims and Objectives

Agency is an important construct across various sciences of learning, arguably most prominently in the sciences of education, philosophy, and psychology. As an interdisciplinary expert group, we examine key insights on how agency is conceptualized in these three disciplines, which are represented by the authors. We use insights from all three disciplines to define guidelines for how agency can be designed for in personalized EdTech. The issue of agency in EdTech is particularly relevant for children given that EdTech play an increasing role in formal and informal education. Moreover, because of their immature cognitive and metacognitive abilities, children often approach learning opportunities differently than adults, suggesting that they need to be supported in developing skills that allow them to play an agentic role in their own learning (Brod, 2021; Marulis et al., 2019). We therefore focused on research directed at young learners when available in the domain. We conclude with concrete examples and provide a rubric of how agency can be designed for in EdTech. This approach allows us to derive robust interdisciplinary guidance for researchers and designers interested in understanding and implementing agency in EdTech. In sum, the article has two major goals:

1. To provide a brief overview of how agency is conceptualized in education, philosophy, and psychology and to synthesize these into an interdisciplinary perspective on agency.
2. To provide guidelines on how agency can be researched and designed for in children's EdTech.

## How Is Agency Conceptualized in Different Disciplines?

### Philosophy Perspective

Philosophical discussion of the nature of agency covers a range of complicated phenomena and crosses different sub-fields including philosophy of action, philosophy of mind and psychology, ethics, aesthetics, and epistemology. One way to roughly map this discussion is in terms of different *types of agency*. These types emerge when philosophers focus on the ways that clustered aspects of normativity impact the expression of agency via actions, practices, and achievements. These discussions are usually offered with respect to one (or maybe two) normative structure(s) at a time, some of which are more directly relevant to the field of EdTech than others:

– Epistemic agency (Sosa, 2015) — This is the kind of agency that is sensitive to epistemic norms (e.g., norms regarding when a belief or action is justified), and to epistemic considerations (considerations that influence epistemic

behavior such as belief updating, evidence assessment, and evaluation of testimony). Discussion here often focuses on the cognitive capacities agents may exercise as they attempt to follow epistemic norms, or on the capacities or modes of social organization that are central to the promotion of epistemic values, like knowledge or understanding.
- Skilled agency (Pacherie and Mylopoulos 2021) — This kind of agency often results from a conjunction of agentive capacities that have been honed by practice and natural talent to produce highly competent or excellent action within or across various domains (e.g., skill at chess, basketball, or painting).
- Aesthetic agency (Lopes 2018) — This is the kind of agency that is sensitive to characteristically aesthetic norms and values or the norms and values common to various aesthetic domains (such as, e.g., painting, sculpture, or musical composition). Discussion here might focus upon the capacities agents have to devise, appreciate, follow, and produce aesthetic norms and values.
- Moral agency (Arpaly 2002, Stichter 2018) — This is the kind of agency that is sensitive to moral rules, practices, and values. Discussion here often focuses on moral learning, or the human ability to understand and follow moral rules, or the practices governing attribution of praise and blame.
- Practical agency (Bratman 2007, Shepherd 2021) — This is a very general kind of agency and concerns the capacities agents have to understand and follow norms of practical rationality, to engage in planning and reasoning, to develop projects that contain multiple goals, and to reason about how best to satisfy these goals.
- Group or corporate agency (List and Pettit 2011) — This is a kind of agency displayed by collections of individuals and often by the embedding of individuals within some social architecture (such as a corporation). Discussion here often focuses on the capacities that groups or institutions have of displaying internal structures and external behavior that is identical or analogous to the structures and behavior that normal human agents display. Such discussion is often motivated by a concern to understand the extent to which groups or corporations can bear responsibility for behavior that is not a product of any one individual, but rather of the group taken as a whole.

While discussions of different types of agency are usually offered with respect to one (or maybe two) normative structure(s) at a time, they clearly interact and overlap in actual humans. All of us are, to some extent, aesthetic agents, epistemic agents, moral agents, and so on. Some of us display high levels of some of these forms of agency; many of us display only minimal competence (or worse) at some of the forms. How these types of agencies relate to one another in common forms of human interaction remains an open area of philosophical and psychological inquiry. In light of this variety, is it fair to say that we do not have a unified philosophy of agency, but rather many philosophical perspectives on many facets of agency.

A complimentary mapping might focus on the fact that much work on agency (often implicitly) characterizes agency as falling along a *spectrum of sophistication*, resulting in various *levels (or degrees) of agency*, where these levels vary according to the reliability, flexibility, and sophistication of the capacities that

constitute agents. These capacities include perceptual modalities and sensorimotor coordination, as well as cognitive capacities such as reasoning, imagination, language, and metacognition. In the philosophy literature, we also find some discussion of agency at different levels of sophistication. For example, we find some discussion of primitive agency of the sort that insects and arguably even simpler organisms display (Burge 2009); there is perhaps slightly more discussion of the agency displayed by non-human mammals (e.g., Steward 2009); and by far, the most attention has been paid to more sophisticated types of agency human agents are capable of, e.g., autonomous agency (Mele 1995), morally responsible agency (McKenna 2012), self-conscious or self-knowing agency (Anscombe 2000), and shared or joint agency (Bratman 2013).

Finally — and promisingly, given our interests in the relevance of conceptions of agency to the development of educational technology — philosophers of agency have recently turned to reflection on the social construction of (aspects of) agency. This has included analysis of the ways that culture, technology, social norms, and practices of socialization (including practices of praising and blaming) scaffold and shape agency from birth to adulthood, for better or worse (see, e.g., Vargas 2013, McGeer 2019). Indeed, Liao and Huebner (2021) have argued that not only other agents, but also things — material artefacts and spatial environments — are often integrated into systems that may be oppressive (racist, classist, sexist, ableist) and thus detrimental to the development of agency.

A challenge in the present-day philosophy of agency is that the discipline has little advanced our understanding of *children's* agency. Instead, children are assumed to represent a paradigm case of less sophisticated, not-fully-formed agency, especially in discussions surrounding legal and moral responsibility. However, a number of ideas drawn from the philosophy of agency more broadly may be relevant to our conceptualization of children's agency. It is clear that agency is a multi-faceted phenomenon, and the influence of our choices regarding educational technology will often impact multiple facets at once. Arguably, educators, parents, and even conspecifics are always building the agency of children, sometimes intentionally, but often incidentally or even accidentally. Thus, we have to ask about the dimensions and aspects of agency that various educational technologies influence, both intentionally and incidentally.

We lack space to discuss in detail how this would go regarding every type of agency, but an example here may help. Let us briefly consider epistemic agency. Since the specific content of the norms that influence belief, action, and assertion enjoys little consensus in philosophy, the value of philosophical discussion of epistemic agency for EdTech development might primarily lay in prompts towards EdTech that allows learners to explore the epistemic space. Children face a complex epistemic landscape of fake news and propaganda alongside facts of various importance, and they also face competing claims about evidence, and competing claims about expertise (i.e., who has authority to make certain assertions). Additionally, we know that some belief updating mechanisms are easy to trick — people are more likely to reject evidence that challenges their self-conception (e.g., Porot & Mandelbaum, 2021). EdTech might be developed in ways that allow children to enhance their epistemic agency — to gain familiarity with

epistemic behavior such as evidence assessment, propaganda detection, and decisions to change one's mind.

Of course, the development of EdTech may take inspiration from philosophical analysis of aspects of agency, but such inspiration needs to be scaffolded by an understanding of educational and psychological factors that drive the development of agency. So, the philosophical perspective on agency must find synergies with these other perspectives.

## Educational Perspective

Education, understood as a human undertaking to gain knowledge, is to a large extent influenced by historical, socio-cultural and political traditions of pedagogies, didactics and national policies. It follows that definitions of agency rely on eclectic approaches and that "an unpacking of the notion of agency needs to be combined with reconnecting agency to the wider social structures in which it is embedded." (Coe, 2013, p. 272). In early childhood education, agency has been substantially theorized and empirically investigated (e.g., Cieciuch, & Topolewska, 2017). In particular, this concerns its relation to identity development from birth to adulthood, building on Erikson's (1963, 1968) seminal work, and its relation to self-awareness and self-relevance in the field of art education (e.g., Dunn, Gray, Moffett, & Mitchell, 2018; Sakr, 2017). Connecting to Giddens' (1984) work, Redmond (2009) defines agency as the "capacity to act" (p. 544) and describes it in terms of the choices available to young children and children's awareness about these choices. The social justice discourse in education argues that educational environments, including digital environments, need to be designed in ways to socially empower children to make their own choices (Vanbecelaere et al., 2020) and to ensure that all children, regardless of background or predispositions, can actively participate in meaning making, literacy, and learning activities (Hempel-Jorgensen, 2015). Learning environments that disregard children's active participation negatively impact their development (Berthelsen, & Brownlee, 2005) and deficit discourses that position children as lacking certain capabilities, including agency, disregard the collective forces that shape the opportunities available to children to express their individuality and particularness (e.g., Mary & Young, 2018; Carela, 2019).

Stenalt (2021) argued for the need for more critical approaches to students' agency in relation to technologies used in higher education and proposed that these should take into account relational, cultural, and technological aspects of student-technology learning interactions. Stenalt's (2021) theoretical framework of digital student agency recognizes the reciprocity between students' and technologies' contributions to a learning situation and considers, for example, use of data or digital self-representation. These insights are useful for adult students who can manage their data or choose who and when others have access to their data (Jääskelä, Heilala, Kärkkäinen & Häkkinen, 2021). For young learners, who are the focus of our work, there is a need to strike an optimal balance between children's independent and adult-mediated agency (Eriksson and Lindberg, 2016). EdTech design can disrupt this balance with features that provide or constrain the space for adult-child

shared and independent interaction. Parents (Montazami et al., 2022a) and teachers (Montazami et al., 2022b) are cognizant of the qualitative differences in EdTech and the choices they offer to children and have expressed the need for more guidance on the types of EdTech that optimally support children's learning and development. Our article taps into that need and considers the implications of children's agency for selection and implementation of EdTech in classrooms, with attention to EdTech design that is most conducive to children's active participation in learning.

Design-based educational research has illuminated the ways in which specific apps and digital books can support children's active contribution in the form of reading, writing, and multimodal composing (e.g., Kucirkova, 2018; Kim, 2022) and the uniqueness of each family in approaching the dynamics of digital storytelling (e.g., Rogers & Bird, 2020). Kajamaa and Kumpulainen (2019) highlighted the influence of creative and power-challenging features of new digital learning environments on children's agency (see also Kumpulainen, Sairanen & Nordström, 2020; Sairanen, Kumpulainen & Kajamaa, 2022), and several qualitative studies conducted in home (e.g., Scott, 2022) and pre-school learning environments (e.g., Ma, Wang, Fleer & Li, 2022) have documented the dynamic ways in which agency manifests in child-adult and child-child interactions with technologies. The close attention to contextual and socially co-constructed facets of children's interactions has been a strength of educational approaches that is only beginning to be considered in relation to children's agency and EdTech.

## Psychology Perspective

In psychology, research focuses on the mechanisms of human agency, including the abilities that allow an individual to exercise control over their thoughts and behavior and their perception of these abilities. Psychology mostly uses the term "agency beliefs" to denote that the psychological mechanism of human agency is an individual's perceived capacity to produce desired effects by their actions (Bandura, 2006). A closely related construct is the *belief of personal efficacy*, which has been suggested as the foundation of human agency and to affect an individual's goal setting and goal striving (Bandura, 1989). Similarly, according to self-determination theory, greater perceived *autonomy* is related to an increased motivation to learn (Ryan & Deci, 2000). A wealth of studies has demonstrated strong links between self-reported efficacy beliefs and motivation, performance, and overall well-being (e.g., Holden, 1992; Multon, Brown, & Lent, 1991). Agency beliefs thus influence how high people set their goals, how they strive to achieve them, and whether they easily give up in the face of difficulties or persist.

Recent research has focused on manipulating agency beliefs by giving people more or less choice (e.g., Bobadilla-Suarez, Sunstein, & Sharot, 2017; Leotti & Delgado, 2011). This research indicates that people actively seek to have choice because they perceive it as intrinsically rewarding. Results of choice preference tasks indicate that people select opportunities that give them choice and that anticipating such an opportunity is associated with increased activity in brain regions involved in reward processing (Leotti & Delgado, 2011). They are even willing to forgo

monetary rewards in order to retain agency (Bobadilla-Suarez, Sunstein, & Sharot, 2017). In sum, in line with Bandura's earlier notions, the perception of having control over one's learning has clear beneficial effects for students' motivation. These beneficial effects of agency may even form a positive flow of effects in that having successfully controlled one learning situation boosts learners' self-efficacy, which then benefits learners' goal setting and goal striving in the next learning situation.

Studies on declarative learning indicate that the perceived capacity to exercise control over one's learning can have beneficial effects for learning as well. Even if students can only control incidental aspects of the learning context, this benefits their engagement in learning and learning test scores (Cordova & Lepper, 1996). Giving them choices that are of high utility likely leads to higher learning gains, however (Katzman & Hartley, 2020; Markant, DuBrow, Davachi, & Gureckis, 2014). Of note, tricking people by giving them perceived but not actual control over the learning content has likewise been shown to improve their memory for the content (Murty, DuBrow, & Davachi, 2015; Schneider, Nebel, Beege, & Rey, 2018). While there is good evidence for a beneficial effect of agency for simple facts learning, there is little evidence concerning more complex learning scenarios, such as when learners are given the choice of which tasks to work on. On the contrary, a wealth of evidence suggests that most students do not know how to manage their learning effectively (e.g., Bjork, Dunlosky, & Kornell, 2013). This leads to ineffective choices such as the selection of too easy tasks or ineffective learning strategies (e.g., rereading, underlining).

The relation between agency beliefs and learning differs between individuals as well. Student characteristics such as their age, knowledge, or metacognitive capacities likely all play a role in determining whether greater autonomy helps or hinders learning (Brod, 2021b). While elementary-school children already prefer tasks that give them some choice (e.g., Brod, Breitwieser, Hasselhorn, & Bunge, 2020), the link between students' agency beliefs and their performance in cognitively challenging tasks has been shown to increase across the elementary and early secondary school years (Chapman, Skinner, & Baltes, 1990).

Besides students' *beliefs* about their agency, the extent to which individuals can exert control over their own learning also depends on their abilities to form intentions, envision future scenarios, monitor their own functioning, and adjust their behavior accordingly (Bandura, 2006). These properties of agency show conceptual overlap with the related constructs of executive functions, metacognition, self-regulation, and self-regulated learning. There is no consensus in the literature to what extent these constructs represent identical abilities or are nested within one another, and it goes beyond the scope of the current article to provide a comprehensive overview of the use of these different constructs in the literature (but see Dinsmore et al., 2008, for a discussion on the theoretical and empirical boundaries between the constructs of metacognition, self-regulation, and self-regulated learning). At the core, these constructs all involve the awareness that individuals have of their own thoughts and behavior and the effort that they make to gain control over them (Dinsmore et al., 2008).

Importantly, metacognition and self-regulation abilities are subject to developmental change. Over the course of development, children are increasingly able to

reflect on their own learning and the way they can adjust their behavior to optimize performance. This allows children to move from a reactive to a more proactive or "agentic" mode of learning (Marulis et al., 2019).

Another related factor to consider in this context is the development of executive functions. Executive functions are a family of mental abilities that play a key role in top-down, goal-directed behavior (e.g., Diamond, 2013; Zelazo et al., 2016). Three core executive functions include inhibition (i.e., the ability to resist inappropriate thoughts or behavior and suppress interference), working memory (i.e., the ability to hold information in mind and work with it), and cognitive flexibility (i.e., the ability to switch between different (mental) tasks or perspectives; see Diamond, 2013, Miyake et al., 2000). These three basic executive functions are essential for more complex cognitive functions such as reasoning, problem solving, and planning (Diamond, 2013) and play an important role in learning and academic achievement (for a review, see Zelazo et al., 2016). As such, executive functions can be considered as a core aspect of self-regulation (Zelazo et al., 2016) or as a means of enabling self-regulation (Roebers, 2017).

Importantly, a wealth of research has shown that executive functions, self-regulation, and metacognition show a protracted development (for reviews, see Diamond, 2013; Roebers, 2017; Marulis et al., 2019). This suggests that children and even adolescents may not be able to control their own learning in the most effective and efficient way possible. In line with this suggestion, a recent experimental study investigated how the ability to actively control study behavior affected later memory performance among kindergarten and elementary-school children (Ruggeri, Markant, Gureckis, Bretzke, & Xu, 2019). It found that the benefit of giving learners control over their studying emerged around the age of six and continued to increase across the elementary-school years. The authors speculated that this might have to do with the ongoing development of cognitive and metacognitive abilities necessary for making effective study decisions (Paris & Newman, 1990). In sum, research suggests that the effect of agency on learning increases at least until the early secondary-school years and likely even longer.

## The Contribution of Philosophy, Education, and Psychology to an Interdisciplinary Perspective on Agency

Reviewing these three disciplinary perspectives on agency suggests that there is no simple definition that can capture the notion of agency. Across philosophy, education, and psychology, we find different ways to emphasize aspects of a complex, multi-dimensional construct. Recognizing the complexity and multi-dimensionality of agency is important for present purposes. For if agency is multi-dimensional, then researchers, designers, and users of EdTech must make choices and offer justifications regarding which dimensions to highlight or nurture, and which to ignore. Importantly, EdTech can find inspiration and guidance by drawing from inter-disciplinary research on aspects of agency.

Considering how the three disciplinary perspectives on agency complement each other, we see most merit in the philosophical perspective in asking and specifying

why agency is important for humans and proposing different types and levels of agency that a learner may have. The educational perspective highlights the dynamic interactions between the child, adult and technology, and the contextually dependent pedagogies that can support learning-relevant interactions. The psychology perspective suggests that giving learners more opportunities to exercise control has beneficial effects on motivation and engagement, which can—provided that the learner has sufficient skills to effectively use this freedom—translate to better learning. Yet, the ability to exercise control is also something that undergoes significant developmental changes, related to the maturation of executive functions and metacognition. In sum, the psychology perspective seems most directly relevant for evaluating and developing EdTech. Yet, the philosophy and education perspectives provide a framework to think about agency and point to the normative aspect associated with EdTech. These perspectives are thus at a high hierarchical level and help frame the more operational perspective of psychology.

Psychological theories suggest that whether agency improves children's learning in the context of EdTech will depend on children's learning prerequisites. Of key importance are their prior knowledge of the to-be-learned content as well as their executive function and metacognitive skills (Brod, 2021a, 2021b). High levels of prior knowledge in the domain of study facilitate organization of to-be-learned material and free up cognitive capacities, which can then be invested in choosing appropriate learning environments and tasks to work on. Conversely, students with low levels of prior knowledge struggle with choosing appropriate learning environments and tasks to work on (Kirschner, Sweller, & Clark, 2006). Executive functions such as working memory, inhibition, and cognitive flexibility facilitate efficient shifting between tasks and underlie the ability to reason about appropriate learning conditions that suit the individual learner. Metacognitive skills refer to students' ability to evaluate their current learning and to initiate corrective adjustments if needed. They are thus crucial for selecting tasks to work on, monitoring learning progress, and evaluating whether to continue with the task. Executive functions and metacognitive skills together enable an effective self-regulation of one's learning (Roebers, 2017).

Research on self-regulated learning combines parts of the educational and psychological perspectives. Effective self-regulated learning is conceptualized as a goal-directed process in which learners consciously make decisions that lead towards their learning goals (Azevedo, 2015). Learners set learning goals to plan their learning and attain these goals by adjusting their strategies (Winne, 2017). They also monitor whether their actions support progress towards their learning goal (Azevedo, 2009). Yet, research has consistently indicated that many learners experience difficulties with adequately self-regulating their learning (Greene & Azevedo, 2010; Järvelä et al., 2013). Consequently, many learners need external support to engage in successful regulation. To complicate issues further, as described above, learners' self-regulated learning is also influenced by learner characteristics such as prior knowledge age, motivation, and context characteristics of the learning environment such as domain and learning topics, emphasizing the need to adjust support to individual learners (Dignath, Buettner, & Langfeldt, 2008). Especially, the latter refers to a body of research around self-regulation enhancing learning environments (Perry, 1998: Dignath & Veenman, 2021). This line of research indicates that

a certain amount of choice in learning is important for metacognitive skills to be able to develop. Hence, students should be given enough agency to make decisions and execute control during learning. This leads us to our second research question concerning the ways in which the different levels of agency can be researched and designed for in EdTech to supports various learner needs and prerequisites.

## How Can Agency Be Researched and Designed for in Personalized EdTech?

With increasingly sophisticated possibilities for adapting content to user characteristics, engagement, and performance, EdTech designers face a dilemma: do they allow learners to choose learning content in the order and ways they prefer, or do they assign "optimal" content to learners selected by data-driven algorithms? When AI provides personal recommendations to individual learners, does it extend or limit students' and teachers' choices in the learning content, activities, and environments they engage with?

As detailed in the previous section, design that maximizes agency by leaving the choice completely up to the learner is likely to lead to ineffective learning because most learners, and particularly younger ones, do not know how to manage their learning effectively. Conversely, design that minimizes learner agency is likely to interfere with learners' self-regulated learning and potentially reduce the development of executive function and metacognitive skills (Molenaar, 2022). Therefore, what is desirable is an EdTech design that adapts agency levels to different learners and changes the level of agency assigned to a particular learner over time. In what follows, we conceptualize what such an adaptive assignment of agency levels by EdTech could look like. To the best of our knowledge, such an adaptive assignment of agency has not been implemented in current EdTech. However, different commercial EdTech applications afford agency in different ways and at different levels. Therefore, we provide some guiding principles along with a table in which we describe specific examples of EdTech design that correspond to different levels of agency. This table can be applied in future EdTech design as well as in research evaluating its effectiveness.

### EdTech and Adaptive Assignment of Agency: Theory and Empirics

Our conceptualization of an adaptive assignment of agency levels to learners resonates with recent proposals to make personalized education more dynamic by adapting to a specific learner at a specific point in time in the instructional process (see Tetzlaff, Schmiedek, & Brod, 2020). Figure 1 shows how these ideas can be applied to assigning different levels of agency to learners. The simplified version of such a personalization loop consists of three steps: (1) Identification and assessment of relevant learner characteristics (e.g., prior domain knowledge, executive function, and metacognitive skills), which form a student model; (2) algorithmic assignment of level of agency to give to the student based on the student model (see Table 2 for

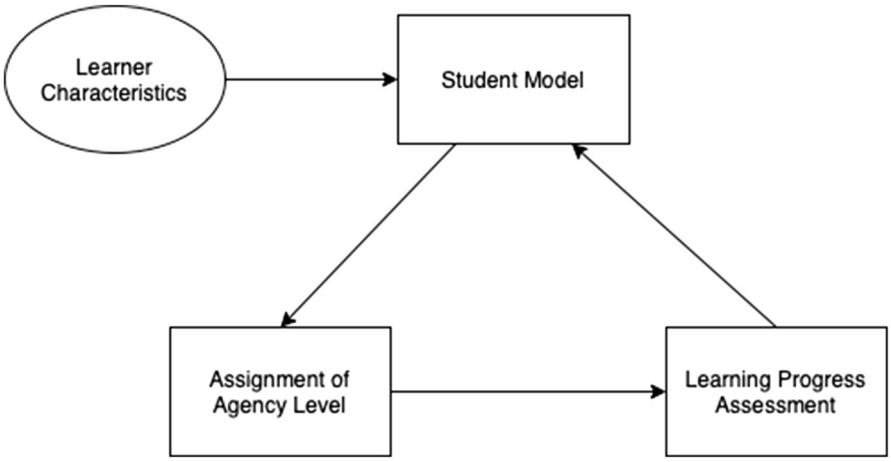


**Fig. 1** Agency personalization loop. Relevant learner characteristics form an initial student model, which determines the initial level of agency given to a learner. The student model, in turn, shows that the assignment of agency level is updated based on measures of task performance

specific examples of agency); (3) learning progress assessment, which uses task performance data to update the student model. Following this personalization loop, the level of agency provided by the EdTech can vary both between different learners and within a particular learner over time.

The proposed agency personalization loop is deliberately generic. It is assumed to be applicable to the various ways in which control can be shared between students and EdTech (see Table 2 below). EdTech, particularly those systems that rely on data-based personalization techniques, allow designers to give different levels of control to different learners and at different time points during the instructional process. We argue that the adaptation process should systematically combine characteristics of the learner with their learning progress to determine the level of agency that the learners are provided with, at different points in time. Examples for what this agency personalization loop can look like in practice have already been provided for one parameter of instructional control—task selection.

Corbalan, Kester, and van Merriënboer (2006, 2011) proposed and tested a *personalized task-selection model with shared instructional control* in which an algorithm preselects a subset of tasks/difficulty levels based on a student model (called *learner portfolio* here) and then allows learners to make the final selection from this subset. The scope of the preselected tasks is inversely related to learners' prerequisites, thus enabling greater choice for more advanced learners. Performance and invested mental effort are assessed during task execution, and these data are used to update the student model. Initial data from the research group (Corbalan et al., 2006) indicate higher learning scores with shared instructional control than with full system control.

In a similar vein, shared control over problem selection has been designed in the context of Intelligent Tutoring Systems (Long & Aleven, 2016). These systems indicate the mastery level of the student on a particular learning objective, which guides

the learner in making the selection of practice activities. In a classroom experiment, Long and Eleven (2016) showed that shared control over problem selection led to better learning outcomes than fully system-controlled problem selection. They also found effects on students' knowledge of problem-selection strategies, but there was no transfer to future learning contexts. Again, this supports the added value of shared control both for learning as well as for the development of knowledge to regulate students' own learning. Taken together, these two examples demonstrate that an adaptive assignment of agency levels to learners is not only desirable but also feasible. Assigning different levels of control over the selection of tasks to students in an adaptive way can benefit both their learning outcomes and their development of self-regulated learning skills.

To summarize, the proposed agency personalization loop suggests that the level of agency provided by the EdTech should be assigned in an adaptive manner, taking into account characteristics of the learner and their learning progress as suggested by psychological research. In this way, EdTech can strike a balance between too much agency, which leads to ineffective learning, and too little agency, which hampers learners' motivation and development of self-regulated learning skills. This aligns also with the philosophical and the educational perspective in that it emphasizes the normative point that children should have agency, as well as in that it takes into account importance of interplay between the learner, the teacher/teaching agent and the environment, and the philosophical perspective in not presuming a neutral technology. To the best of our knowledge, such an adaptive assignment of control has not been implemented for other types of instructional control (e.g., task content, appearance), nor has it been widely implemented in EdTech tools. Therefore, in the final section of the manuscript, we will sketch guiding principles for what adaptive EdTech design for agency can look like and how it can be implemented in both design and educational practice. To make these principles as concrete as possible, we will present examples of existing EdTech application that differ in how and to what extent they afford agency to users.

## EdTech and Adaptive Assignment of Agency: Design and Practice

Table 1 provides guiding questions and corresponding examples of the ways in which agency can be researched, understood, and designed for in EdTech. The questions are thought to guide both the theorization of agency in technology-enhanced learning contexts and the practical development of EdTech. The questions reflect the insight of the philosophical perspective that different types and levels of agency should be distinguished and ideas from the educational and psychology perspectives on what can be controlled by children. The ordering along *wh*-questions (i.e., what, when, where, who) is intended to illustrate that there is no hierarchy among the options, nor is it the case that learner agency either is or is not present. Rather, EdTech designers need to aim for striking an optimal balance between the various options available to learners at different points in their learning journey. For instance, young students who do not have the cognitive capacity and prior knowledge to make effective decisions regarding their own learning path could be given choices regarding the problem selection as

**Table 1** Guiding questions and examples of the ways in which agency can be researched, understood, and designed for in EdTech

| Guiding questions | Examples of design levers (features or actionable dimensions) |
|---|---|
| What can be chosen? | - Content of the activity |
| | - Progress of the activity |
| | - Appearance of the activity |
| | - Learners' self-representation (avatar) |
| Who has choice? | - Learners have full agency |
| | - Shared between EdTech and learner (e.g., prespecified list of options) |
| | - Shared between EdTech and teachers/parents |
| | - EdTech have full agency |
| When can choices be made? | - At the starting and end points of the activity |
| | - At specific milestones during the activity |
| | - Throughout the activity |
| Where can choices be made? | - In the main user dashboard |
| | - Within an activity window |
| | - At the avatar level |

discussed above, which may increase their ability to exert control without sacrificing learning effectiveness. Yet, older students or more advanced learners may experience additional benefits when they are given more autonomy regarding the task content and progression. In fact, a task that provides high levels of guidance may even be *disadvantageous* for more advanced students, an effect known as the "expertise-reversal effect" (Kalyuga, 2007).

Table 2 is intended to provide some concrete examples of how agency can be implemented in EdTech. It is thus intended to concretize the design levers listed in Table 1. In accordance with the notion of different types and levels of agency, we separate *what* can be controlled (i.e., content, sequence, appearance of an activity or task as well as learner's self-representation) from *who* is exerting the control (i.e., student, EdTech or shared by teacher and student). To make the individual criteria in the table as specific as possible, we provide illustrative examples of existing EdTech. In selecting these examples, we drew upon popular EdTech that are advertised as supporting children's language and/or literacy learning (i.e., reading, writing, vocabulary) in the UK/US app stores. We believe that bringing EdTech designers and interdisciplinary researchers together would be a good way to advance an evidence-based approach to agency in EdTech. The guiding questions can be a good starting point for this exchange.

## Conclusions

### Theoretical Contributions and Limitations

Our interdisciplinary review of the agency literature revealed that there are different types and levels of agency and various prerequisites for an effective exercise

**Table 2** Implementing agency in EdTech: examples for *what* can be controlled (columns) and *who* is exerting the control (rows). Examples of existing EdTech solutions are in italics

| What is controlled<br>Who exerts control | Sequence or progression of activities | Content of an activity | Appearance or style of an activity | Students' self-representation |
|---|---|---|---|---|
| Student has full control | Students determine all aspects of the activity flow.<br>*Squla app: Students freely select the activity type (e.g., quiz, game, film).* | Students create their own content.<br>*Our Story app: Students make their own story, including story plot and story characters.* | Students determine the appearance of the EdTech in terms of all modalities.<br>*Book Creator app: Students decide on the colors, types of sounds or texts for their stories.* | Students create their own avatar.<br>*Voki app: Students create customized avatar (including outfit, voice, background).* |
| Shared between student and EdTech | Students can influence some parameters of the activity flow.<br>*Memrise app: Students are guided through the courses but can choose activities within them (e.g., flash-cards, games).* | Students can choose content from a selection.<br>*Fairytale Play Theater app: Students are provided with story templates to mix and match to create a story.* | Students can choose some but not all stylistic/aesthetic features.<br>*My Story app: Students can choose colors and font of the text in their stories.* | Students can choose and/or modify existing avatars.<br>*Words with Ibbleobble app*: Students choose a character companion from a list. |
| Shared between EdTech and teacher | Activity flow determined by teacher and EdTech<br>*BoomWriter app: Students are provided with the first part of a story that was written by a professional writer and selected by their teacher. After that, the students write the rest of the story themselves.* | Teachers can choose content from pre-selected products/assets.<br>*Epic! Digital library: Teachers can assign specific e-books to children or they can assign general themes to children and let children choose the books within particular themes* | Teachers can adjust the style of the activity based on EdTech's suggestions and students' contributions.<br>*MyON app: Teachers can support children's reflections on the MyON e-books they read with pre-designed graphical organizers.* | Teachers have their own avatars, together with the students.<br>*Zoo U app: Teachers can control the game in the role of avatars to train children's social skills.* |

**Table 2** (continued)

| What is controlled<br>Who exerts control | Sequence or progression of activities | Content of an activity | Appearance or style of an activity | Students' self-representation |
|---|---|---|---|---|
| EdTech has full control | Activity flow determined by EdTech<br>*Gynzy app: Sequence is determined and based on students' ability.* | Content selected by EdTech<br>*Jack the Beanstalk app: The story is fully provided at the outset.* | Students cannot make any adjustments to what the EdTech looks like.<br>*Epic stories app: The layout and reading mode of the stories are fixed and offered as a set.* | Students are given an avatar.<br>*World's Worst Pet – Vocabulary app: Students follow a pet companion.* |

of agency and that these undergo developmental change. Moreover, the psychology literature shows that it is not only agency itself but also students' beliefs about agency that should be taken into account. By bringing these insights together, we have extended mono-disciplinary approaches to agency and described implications for how researchers study children's agency in different contexts and with different resources. While our conceptualization of agency draws on three key disciplines of the learning sciences, it does not include insights from anthropology, sociology, neuroscience, or other related disciplines. Future research could usefully expand our initial formulations with further theoretical insights from these and other disciplines.

### Design Contributions and Limitations

Our proposed agency personalization loop suggests that EdTech designers must make choices and provide justifications for which dimensions to emphasize and which to ignore when designing various contents, activity flows, and learner representations. The level of agency provided by EdTech should be assigned in an adaptive manner and strike a balance between allowing children to freely choose learning content and assigning optimal content to them. We chose to look specifically at young learners because we think that the issue of developing agency is most pressing there. In addition, we pointed out that control can also be shared between EdTech and teachers. While this reduces the agency of the child, it has the advantage that the teacher knows the child well and is therefore particularly able to support them. We suggest that in future EdTech design, attention should be paid to what can be controlled by learners as they progress their learning and to what extent this helps or hinders their learning and development.

### Practice Contributions and Limitations

When teachers offer learners unlimited choices, it can lead to ineffective learning. But if they control children's choices too much, they can hamper children's motivation and development of self-regulated learning skills. Given the variety of EdTech and the uneven quality of EdTech solutions on the market, teachers need to carefully select which EdTech they use in the classroom. We suggest that teachers reflect on students', EdTech's, and their own levels of agency in an activity and apply our guiding principles for selecting appropriate EdTech products. Given that more agency does not always translate into enhanced learning, and optimal levels of agency differ between learners as well as within a particular learner over time, the extent of agency should be adapted to the specific learner in a systematic manner.

In conclusion, EdTech has to take into account the dynamics of children's agency, and we have provided both an interdisciplinary perspective on the topic and practical guidance on how to do so. In this way, educational technologies can strike an optimal balance between learning effectiveness and learner engagement and thus better deliver on their promise of being *educational.*

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**Conflict of interest** Natalia Kucirkova led the development of the freely available 'Our Story' app at the Open University, UK.
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