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Investigating Diverse Research Orientations in Smart Learning Ecosystems: Uncovering Positive and Negative Impacts on Learners' Learning Smartness

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1 Introduction

In response to the TIMISOARA declaration on the future of smart learning ecosystems, this stimulated paper critically examines the potential impacts of smart learning environments/ecosystems on learners' agency beyond content and skill mastery. The declaration emphasizes the role of technology in achieving people-centred smartness in education [6], but the core issue to scrutinise is the differences between "smartness of technology" and "smartness of learners". I would like to approach this issue in two dimensions: three major orientations of educational technology research, and the distinction between system adaptivity and adaptability in the context of software engineering.

Educational technology research can be broadly categorized into three major orientations: dream-based, adoption-based, and humanity-oriented (known as "humanity-based" in the original literature), as proposed by [5]. These orientations should be viewed as forming a spectrum rather than distinct types. While they offer valuable contributions and insights into the diverse approaches within the field in their own ways, each has its own limitations and challenges.

Dream-based Research. The dream-based research orientation exhibits a commendable ambition in pushing technological boundaries and exploring novel educational technologies. However, it is observed that this approach sometimes lacks a robust theoretical framework to support its innovations. While the pursuit of innovation is admirable, a stronger emphasis on theoretical grounding could further enhance the alignment of these technologies with established learning theories [10]. By incorporating a more robust theoretical foundation, researchers in this orientation could ensure that their innovations better address the diverse pedagogical needs of learners, ultimately leading to more effective learning outcomes.

Adoption-based Research. In contrast, adoption-based research is informed by established learning theories and pedagogies. Researchers in this orientation recognise the importance of theoretical underpinnings in the design and implementation of educational technologies. They adopt or synthesise existing technologies that are supported by empirical evidence and align with pedagogical principles. Adoption-based research may address cost limitations by leveraging off-the-shelf tools or combining multiple tools to create innovative learning environments or ecosystems. By grounding their work in established theories, researchers in this orientation ensure that

their educational technologies are effective and pedagogically sound. Yet such research may sometimes prioritise practicality over innovation and fail to address emerging educational needs adequately. Still, "exploring novel ways of applying existing tools" presents itself as an alternative avenue for praiseworthy and potentially effective innovation [3].

Humanity-oriented Research. Humanity-oriented research prioritises learner autonomy without over-reliance on technology [7]. Researchers in this orientation aim to develop learners' dispositions and cognitive skills in lifelong autonomous learning, personal interests, values, and self-actualisation. The focus is on empowering learners to take control of their own learning processes and become independent and self-regulated learners. While technology may play a supportive role in humanity-based research, the emphasis is on fostering human-centred learning experiences that transcend technological tools. By promoting learner agency and self-determination, such research prepares learners for success in the digital age and beyond. Yet this orientation, if applied in isolation, may struggle to balance autonomy with technological support, potentially overlooking how emerging technologies can augment learning experiences and even redefine educational paradigms in the decades to come [12].

2 Critiquing the Orientations and Expanding Beyond 2030

These three orientations are not mutually exclusive but complementary. Dream-based research provides the innovative foundation, adoption-based research ensures practical and pedagogical relevance, and humanity-oriented research focuses on long-term learner development. Looking toward 2030 and beyond, these orientations must converge, evolving into a unified framework that can respond to future educational needs and technological advancements. For instance, the integration of humanity-based principles into dream-based research can ensure that emerging technologies foster rather than diminish learner agency.

Building on [9] argument for integrated thinking and competencies that differentiate humans from AI, future research must emphasise the holistic development of learners. Life skills, socio-emotional competencies, ethical reasoning, and creative problem-solving—skills that highlight the "supremacy" of humans over machines—must be at the core of smart learning ecosystems beyond 2030. By incorporating these human-centric competencies, smart learning ecosystems can prepare learners for an uncertain future while retaining the humanity that defines education.The distinction between adaptivity and adaptability [13] holds significant implications

3 Adaptivity and Adaptability in Future Smart Learning Ecosystems

The distinction between adaptivity and adaptability [13] holds significant implications for the design and implementation of smart learning ecosystems, particularly

concerning their impact on learners' development. Adaptivity, characterised by the automatic adjustment of system behaviours based on user interactions, represents a form of technological support aimed at enhancing learning experiences. Conversely, adaptability empowers users to configure the system according to their preferences and needs, fostering learner agency and autonomy.

Drawing parallels to the functionalities of automatic and professional cameras, an overemphasis on adaptivity within smart learning ecosystems may inadvertently shift the focus from teacher-centred pedagogy to technology-driven instruction. In such scenarios, learners may become overly reliant on technology to guide their learning processes, potentially hindering the cultivation of essential skills such as critical thinking, problem-solving, and self-regulated learning. Thus, it is imperative to strike a balance between adaptivity and adaptability, leveraging the benefits of technological support while promoting learners' agency and autonomous learning abilities within smart learning environments or ecosystems.

Moving on, the rise of Generative AI for public use in recent years has introduced an unprecedented level of accessibility to smart technologies. This has triggered a wave of "fear" among educational technology researchers – many of whom are also university educators —who are now starting to recognize the risks associated with over-adaptivity. The concern is no longer hypothetical but increasingly tangible: if learners become overly reliant on adaptive technologies to drive their learning processes, it may undermine the development of critical skills such as problem-solving, self-regulation, and adaptability [4,8].

This shift in awareness among researchers and educators signals a pressing need to "re-develop" learners, not merely as users of technology but as autonomous agents capable of navigating and leveraging these tools without being dominated by them. If this effort is not undertaken with urgency, the drawbacks of over-adaptivity will become entrenched, leading to educational environments where learners are passively guided by systems rather than actively shaping their learning trajectories. In contrast, adaptability ensures that technology serves as a facilitator rather than a dictator of learning processes, promoting agency and empowerment rather than dependence.

Scardamalia et al.'s argument [14] reinforces the importance of maintaining a learner-centred approach in educational technology design and implementation. As she argues,

> *"It is not the computer that should be doing the diagnosing, the goal-setting, and the planning. It is the student. The computer environment should not be providing the knowledge and intelligence to guide learning, it should be providing the facilitating structure and tools that enable students to make maximum use of their own intelligence and knowledge."*
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> (Scardamalia et al., 1989, p. 54)

This perspective aligns closely with [15] call for extending adaptability beyond technological systems to include the learning experience as a whole. Future smart learning ecosystems must enable learners to navigate seamlessly between digital and physical environments, leveraging technology as an augmentation tool rather than a prescriptive system. This adaptability of the learning experience is crucial for fostering

learner agency and ensuring that learning extends beyond the confines of technology [2].

4 Measuring Student Progress for Effective Adaptivity and Adaptability

One of the challenges in designing adaptive systems is how to measure student progress in ways that inform the modulation of adaptivity and adaptability. Dream-based research, for example, often neglects the granular data needed to achieve effective adaptivity. By integrating robust learning analytics frameworks, such as learning analytics or competence-oriented measures, researchers can design systems that better align with learners' progress and needs [1]. Humanity-oriented research can extend this focus by measuring not only content mastery but also the development of transversal competencies, such as ethical reasoning, collaboration, and problem-solving. Such measures ensure that adaptivity supports the scaffolding of foundational skills, while adaptability enables learners to take ownership of their educational journey.

5 Implications for Educators Preparing for 2030 and Beyond

To prepare educators for teaching in smart learning ecosystems beyond 2030, professional development programs must focus on fostering a deep understanding of adaptivity, adaptability, and learner-centred pedagogies. Teachers must learn to balance the use of adaptive technologies with strategies that encourage creativity, collaboration, and critical thinking. For instance, adaptive learning tools can act as scaffolding that fades as learners gain proficiency, empowering them to take ownership of their learning journey [11].

Moreover, educators must be equipped to evaluate the potential of emerging technologies to support not just content mastery but also the holistic development of learners. By adopting a forward-looking perspective, educators can ensure that smart learning ecosystems remain aligned with human-centred values, people-centred smartness, and pedagogical principles [16].

6 Visualising the Framework

To better illustrate the relationships between the three orientations—dream-based, adoption-based, and humanity-oriented research—a two-dimensional framework is proposed (see Figure 1). This framework enables a clearer understanding of where specific research approaches fall and their implications for the design and implementation of smart learning ecosystems.

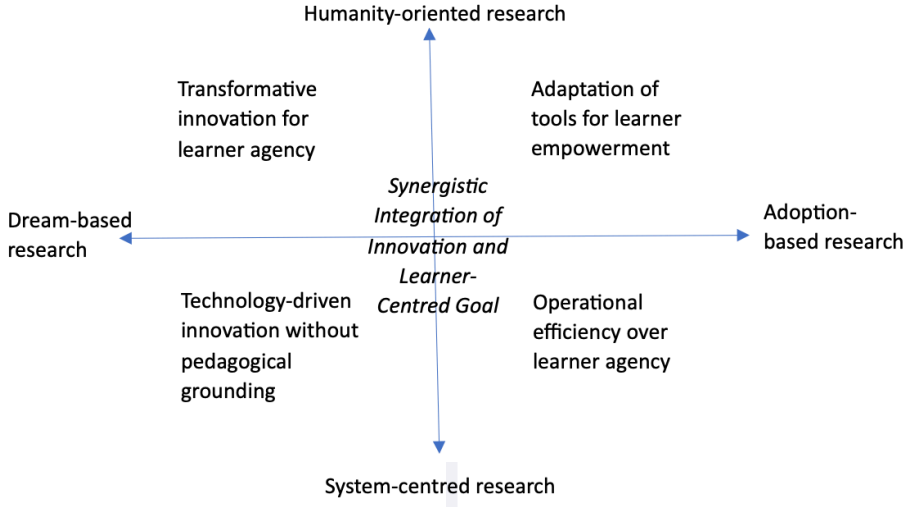

Fig. 1. The Orientations-Agency Framework for Future Smart Learning

The horizontal axis represents the technological focus of research, stretching from dream-based research (pushing technological boundaries) on the left, to adoption-based research (leveraging and repurposing existing tools) on the right.

The vertical axis reflects the learner-centred focus, moving from humanity-oriented research (promoting learner autonomy and agency) at the top, to approaches with a low humanity orientation at the bottom (e.g., technology-driven or operational efficiency without fostering learner agency).

Quadrant 1: Top-Left (Transformative Innovation for Learner Agency). Research in this quadrant represents dream-based innovation that prioritizes learner agency and autonomy. Examples include futuristic tools designed to scaffold and enhance learners' ability to think critically, self-regulate, and adapt. These technologies aim not just to innovate but to embed human-centred goals within technological advancement.
Toward 2030 and Beyond: Researchers and policymakers must encourage transformative innovation that aligns smart systems with the principles of lifelong learner empowerment. This quadrant holds potential for forward-looking solutions that prepare learners for uncertain and evolving futures.

Quadrant 2: Top-Right (Adaptation of Tools for Learner Empowerment). This quadrant encompasses adoption-based research that repurposes and integrates existing technologies to support learner autonomy. Examples include personalisation frameworks, collaborative tools, and adaptive learning systems that enable learners to take control of their learning processes.
Toward 2030 and Beyond: This orientation offers scalable, realistic pathways for educators and policymakers to advance learner agency while maximizing the value of existing tools. It balances innovation with immediate impact, promoting sustainable, human-centred ecosystems.

Quadrant 3: Bottom-Left (Technology-Driven Innovation Without Pedagogical Grounding) In this quadrant, dream-based research prioritizes technological advancement without grounding innovations in pedagogical goals or learner needs. Highly adaptive systems risk overwhelming learners or fostering over-reliance on technology, diminishing critical skills like problem-solving and self-regulation.
Toward 2030 and Beyond: Policymakers and researchers must critically evaluate technology-driven innovations to ensure they augment—rather than replace—learners' agency. Systems that "overdo" adaptivity without a clear learner-centred vision will hinder long-term educational progress.

Quadrant 4: Bottom-Right (Operational Efficiency Over Learner Agency). This quadrant reflects adoption-based research that prioritizes operational efficiency (e.g., cost, scalability) without enhancing learner agency. Examples include tools focused solely on short-term performance gains or administrative functionality.
Toward 2030 and Beyond: While such systems address immediate institutional needs, educators must ensure they do not sacrifice transformative learning goals. Balancing efficiency with learner-centred design is essential for fostering adaptability and lifelong learning skills.

Centre: Synergistic Integration of Innovation and Learner-Centred Goal. At the core of the framework lies the balanced approach, representing research that successfully integrates technological innovation with a strong focus on learner agency and autonomy. Achieving this synergy ensures that technology serves as a scaffold, gradually fading to empower learners as self-directed agents of their learning journeys.

This framework provides a lens to evaluate the direction and purpose of smart learning ecosystem research:

1. For Researchers: The framework underscores the need to position innovations thoughtfully along the axes. While advancing technology, research must also maintain a focus on learner empowerment to ensure long-term impact.
2. For Policymakers: The quadrants offer a guide for evaluating and funding research that prepares learners for 2030 and beyond, prioritizsing balanced approaches that synergize innovation and learner agency.
3. For Educators: Teachers should advocate for systems that scaffold learners' autonomy, fostering skills for lifelong learning rather than passive compliance or short-term performance gains.

By critically examining where research efforts fall within this framework, stakeholders can prioritize pathways that align smart learning ecosystems with the evolving demands of education beyond 2030.

7 Conclusion

This paper highlights the importance of understanding the potential impacts of smart learning ecosystems on learners' development of learning smartness. By critically examining diverse research orientations, incorporating human-centric competencies, and balancing adaptivity with adaptability, we can design smart learning ecosystems

that empower learners for success in the digital age and beyond. Looking toward 2030 and beyond, educators, researchers, and policymakers must collaborate to create ecosystems that enhance learning experiences while preserving the humanity that defines education.

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