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Sumita Sharma | Netta Iivari | Ole Sejer Iversen | Yasmin Kafai | Alissa N Antle | Marianne Graves Petersen | Marianne Kinnula | Christian Dindler | Fares Kayali | Elizabeth Bonsignore | Charu Monga | Marie-Monique Schaper
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Introduction to the Special Issue – Editorial

This special issue emerged from the workshop *Pushing the Boundaries of Computational Empowerment of Children*, held at the Interaction Design and Children (IDC) 2025 conference. The workshop examined how children can build the capacity to critically and creatively engage with digital technologies, exploring, questioning, and shaping both the technologies themselves and the effects on their lives, communities, and everyday environments. It highlights children's ability to participate meaningfully in the design and development of technology, as well as to critically examine its underlying structures, assumptions, and societal impacts. At the same time, it promotes a constructive and future-oriented perspective that emphasizes opportunities for positive change rather than focusing solely on risks and concerns. A key aspect of this approach is fostering collective transformative agency—the ability of individuals and communities to understand and adapt to digital technologies while also reimagining, reshaping, and directing them toward more inclusive, democratic, sustainable, and desirable futures.

This special issue opens with a manifesto developed by the IDC 2025 workshop organizers through months of online and in-person collaboration. The manifesto serves as a call to action for researchers working with children, inviting them to commit to a vision of computational empowerment that reflects a collective aspiration for a more equitable, inclusive, and desirable future for children. Grounded in years of research and sustained engagement with young people in an increasingly digitalized society, the manifesto articulates a shared perspective on how children can meaningfully participate in shaping technological futures. The manifesto begins with a series of vision statements that express our core principles and aspirations for computational empowerment. It then translates this vision into research and design practice by outlining a set of thoughtful, actionable commitments that researchers and practitioners can adopt to support children's critical, creative, and transformative engagement with digital technologies.

The other papers in the special issue are the positions papers submitted to the workshop by researchers from around the world. The papers received constructive reviews from by the workshop organisers and the revised versions are reproduced in this special issue. The papers present diverse perspectives from diverse participant groups engaged by Child-Computer Interaction researchers committed to computational empowerment of children and youth. In "A Pragmatic Approach to Computational Empowerment", Bilstrup et al. argue for a pragmatic approach to critical engagement (CE) where participant turn critical awareness of digital technologies into collective, sustainable action. Clemmensen and Yubing employ the Theory of Planned Behavior to study how culture, design, and social influence shape Chinese children's digital behavior. The paper "From Control to Digital Co-Agency: Reimagining Child Online

Ethical Safety" discusses how child online safety should shift from parental surveillance to autonomy-supporting, co-agential systems that build children's self-regulation and digital resilience through ethical, explainable, and privacy-preserving design. Liu et al. combine dialogic learning and formative assessment to better support, measure, and sustain Computational Empowerment by strengthening learner agency and critical reflection. Om et al introduce Storying-Roleplay, a co-design method that uses storytelling and roleplay to help young children develop early problem-framing skills and computational empowerment. Satavlekar et al. extend Computational Empowerment to "Everyday CE," emphasizing inclusive, mobile-first, low-barrier approaches that support underrepresented students' everyday engagement with digital technologies. In "Supporting Criticality in Computational Empowerment", Veldhuis et al critique technosolutionist approaches in Computational Empowerment and proposes the "design rebel" role to legitimize dissent, subversion, and critical engagement in learning. Weixelbraun and Göbl argue that Computational Empowerment depends on properly preparing teachers through curriculum reform, training, resources, and policy support to bridge current implementation gaps. Together, these studies suggest that advancing Computational Empowerment requires coordinated changes in pedagogy, design, and policy that centre learner agency, critical engagement, and context-sensitive support across diverse educational settings.

Manifesto for doing Research in Children's Computational Empowerment

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1 We position children as co-creators and change agents

We recognize that children possess valuable expertise grounded in their everyday lives, and that this expertise must actively shape decisions about their digital technologies (Nygaard, 1975). We create opportunities for children, as part of their everyday collective practices, to develop the knowledge, skills, and language needed to participate meaningfully in decisions about the digital technologies that affect them (Dindler et al., 2020; Antle and Hourcade 2022). This makes it possible for children to act as legitimate co-creators of shared digital worlds (Bjerknes et al., 1987) through active engagement in the design and governance of technologies and expression of their views within collective settings.

Simultaneously, we recognise children as active agents, inherently capable of enacting transformative change by questioning entrenched norms, identifying injustices, and imagining alternative possibilities (Stetsenko, 2020; Sannino, 2022). In this capacity, they interrogate who truly benefits from technology, whose voices are marginalised or excluded, and how existing structures might be challenged and reimagined (Dindler et al., 2020; Iversen et al., 2025; Veldhuis 2025). Through collective inquiry, creative imagination, and shared action, children demonstrate that digital technologies are not immutable, but can be reshaped and reconfigured in alignment with their own values (Dindler et al., 2020; Iversen et al., 2025).

2 We nurture curiosity and critical exploration of digital technologies

We value creating participatory spaces where children can both design and learn about digital technologies, sparking their curiosity, challenging their assumptions, and encouraging reflection on the limitations and societal implications of digital technologies. In these spaces, children are engaged as users, evaluators, critics, co-creators and contributors in our digitalized society (Druin, 2002, Ventä-Olkkonen et al. 2024). Such engagement can occur through reflective dialogue, hands-on exploration, and democratic participation in shaping the digital world. Linked with this, we regard knowledge as co-created (Freire, 1992). Learning happens in conversation, in shared experiences, and in moments of mutual discovery. This entails learning to imagine the future we want to live in. For this, we must collaborate with individuals, groups, and organizations to explore how current and emerging technologies can support children in their specific contexts and to help children recognize that they have alternatives (Bødker, 2003).

3 We foster care, empathy, and planetary responsibility

We embrace relational perspectives (Niaz et al. 2026) to nurture empathy and care, inviting children to explore how humans, technologies, and the environment can live together in mutual respect (UNICEF, 2024). We foster a sense of responsibility for shaping socially sustainable digital technologies that support the well-being of people and the wider living environment alike. Through collective reflection and exploration, children learn to view digital technologies not merely as tools but as elements within shared ecosystems – encouraging thoughtful design, ethical use, and compassionate engagement with both human worlds and beyond that (Giaccardi & Redström, 2020).

4 We support children in envisioning and nurturing inclusive futures

The past, present, and future are intertwined. Designing for the future requires critical exploration of today's challenges and opportunities, all of which are rooted in our diverse histories and lived experiences—shaping not only our present, but also our imagination of what might be possible (Kinnula et al. 2025). We make this linkage visible to children and invite them from across the globe to imagine and uncover possibilities for alternative futures—individually and collaboratively—foregrounding their voices, values, aspirations, and diverse viewpoints, and supporting them in envisioning inclusive futures (Kenny et al., 2025; Malinverni et al., 2025; Sharma et al., 2024). We foster individual and collective dreaming of alternative and diverse futures, broadening agency, empowerment, and participation across diverse stakeholders and practitioners within the research community on computational empowerment (Schaper et al., 2023). By nurturing children's capacity to imagine future technologies and thoughtfully examine their potential impacts and consequences, we embed democratic values in technology design and practice (Van der Velden & Mörtberg, 2013; Bannon et al., 2018; Antle and Hourcade 2022).

5 We cultivate hope, aiming for just transformations

We regard hope as a catalyst for agency and collective action—not as mere wishful thinking, but as a purposeful means of envisioning and actively pursuing radical futures with technologies that are liberated from oppression and grounded in justice and democracy (Freire, 1970). For us, hope is inseparable from critical awareness: an ongoing process of recognizing and interrogating the world's complexities and contradictions, which arise also in children's interactions with technology. Such critical awareness is not an individual achievement; it is fostered with dialogue, reflection, and collective engagement. We use methods that orient thinking towards just transformations, grounded in the hope for better futures for all. This means moving beyond fear and resignation as regards technology (Kinnula et al. 2025) towards opening spaces

for imagining alternatives and taking collective, concrete steps toward technological futures rooted in social justice (Antle and Hourcade 2022).

6 We promote frameworks and infrastructures for computational empowerment

We must acknowledge our role as agents of change with responsibility to the children we work with. As researchers and practitioners, we commit to provide the physical and ideological spaces and infrastructures for computational empowerment and for sustainable and scalable change– caring about the world we create, promote, and leave behind, and creating lasting impacts from our work (Antle, 2017; Read et al, 2025). We commit to sharing findings with researchers, participating children, schools, and society, creating impact beyond research (Antle 2017; Antle and Hourcade 2022; Read et al., 2025). We must look beyond projects to the infrastructures we build, the changes we make, and the legacy we leave as Child–Computer Interaction researchers and practitioners. We strive to support implementations in schools and across the broader formal educational system. This includes teacher education to computationally empower teachers, to change the perception of roles of teachers and their students, and to further the embedding of computational empowerment in competence frameworks and educational policy (Göbl et al., 2023).

7 Call for action

What can you do—today—to help make this vision possible? What concrete steps can you take to move us toward it? Every small act contributes to larger change. This is work we share, and we undertake it together.

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A Pragmatic Approach to Computational Empowerment

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Abstract

Our societies are becoming increasingly complex due partly to the domestication of generative models and recommendation systems fueled by AI technologies. With these technologies developing at a rate that is difficult for society to keep up with, the implications and ethics of digital systems are also getting more complex. This, in turn, complicates how children and youth can be computationally empowered in a context where it is difficult to distinguish hype from real implications of AI technologies, and ethics operate in unexplored areas and are constantly changing with technological development. We argue that teaching a more pragmatic approach to the implications of digital technologies can serve to empower children and youth – ultimately giving them transformative agency. In this article, we will elaborate on this pragmatic approach before we discuss its application through analyzing three of our cases.

Keywords

Computational empowerment, computational thinking, pragmatism

1 Introduction

In the Computational Empowerment (CE) community, we aim to give children and youth sustained agency in a complex digital landscape [17], and we are ambitious about this goal. We seek to support them in adopting a protagonist role in relation to digital technologies, ultimately driving the development of digital technologies and critically reflecting on the personal and societal consequences [14, 16]. Recently, there has even been an argument for focusing on giving children transformative agency [13], described as "children's ability to transform the knowledge acquired (in school or design) to action and change their own matters, their shared matters, or even societal matters.". This new focus point reflects the traditions and theories of participatory design (PD) roots of CE [15]. However, contemporary PD projects have been criticized from within the PD

community for neglecting how their research contributes to more participation and empowerment beyond the research projects, as well as not engaging with real technology and complex infrastructures [9]. CE projects have sought to address this critique, and there are multiple examples of research projects working with educational infrastructures and with real educational technologies to sustain CE ideas and bring research from more exploratory projects into the classrooms [e.g., 1, 4, 8].

However, we argue that it is not enough to work with infrastructures in how we design and organize CE projects, and in how we build educational tools. If we want children and youth to have transformative agency beyond research projects, what they are taught in the classrooms must also support them personally in engaging with real technologies and complex infrastructures. In this position paper, we discuss how a pragmatic approach to CE can address this issue. With pragmatic, we mean both a pragmatic approach to education, where students engage with society's moral issues and risks [11], and a pragmatic approach to ethics around digital technologies [20].

2 Exposing the Practical and Ethical Complexity of digital

Many classroom design activities are structured to support students in fulfilling ethical principles and goals through digital technologies [24]. Students often work with ethics from an idealistic perspective, e.g., the UN's sustainable development goals, to initiate constructive dialogues on the impact of technologies. Such ethics have, however, been demonstrated as difficult to apply in practice, because they do not deal with technical limitations and tensions between different ethical principles and stakeholder values [25]. They are often abstracted to 'a point of agreement' where political conflicts, diversity of values, and uncomfortable trade-offs are unaddressed [22]. Thus, the difficult ethical decisions that require critical reflection and trade-offs between conflicting values are happening in the development and integration of the technologies (or are not happening at all). In our own research, we have demonstrated how hands-on engagement with the practices and possibilities of digital technologies is crucial for students' abilities to critically reflect on the implications of technologies [5, 6, 19]. Through making judgments in hands-on activities where they are bound by the limitations of the technologies and conflicting interests in the context they design for, students must critically reflect on the benefits and harms of their own designs to make trade-offs. This can be a trade-off between efficiency and privacy: E.g., is it possible to build an ML system that helps lonely peers without collecting their personal data and risking exposing their loneliness? (see example in [6]). Or it can be a trade-off between personalization and citizenship: E.g., is their ML model to analyze voter behavior a tool to understand and communicate with voters more efficiently, or does it manipulate and violate voters' autonomy as independent opinion makers? (see example in [19]). With this, we highlight that teaching how to critique digital technologies from a high-level ethical standpoint may not teach children and youth how to make decisions and trade-offs about real technologies.

Further, this perspective highlights the importance of exposing the practical and ethical ambiguities around emerging digital technologies in educational activities. One example would be the case of misinformation, where research has demonstrated that unreflective critique of misinformation on social media is counterproductive [23]. In reality, only a small part of online information is misinformation, but when people are

told it is a big issue, they start to distrust information. This creates wider issues with information and communication, for example making it easy for dishonest public figures to deny unfavorable stories about themselves. In this way, teaching an unreflective critical stance towards how social media spreads information can make students distrustful. Instead of placing focus on one specific pitfall, we should instead engage with the nuances of information sharing and the opportunities and challenges which come with it (the echo chambers of social media may also be an oversimplification [10]). Similarly, researchers have argued that focusing on future dystopian scenarios of AI serves to remove the focus from the current, very urgent environmental and societal implications of AI [21]. This is seen in how commercial actors oversell LLMs as the idea of general intelligence and how the public debate becomes centered around the prospects of such a perfect, general-purpose AI rather than engaging with the implications of the current powerful-but-flawed technology. Lastly, in our own studies, we have experienced how teaching about the danger of sharing data and representing social media technologies that students use as something bad can make students feel disempowered [5] because this perspective does not address the reasons why students use and enjoy these technologies.

These examples serve to demonstrate the basis of our thoughts toward a more pragmatic approach to CE. In the following, we will try to demonstrate how this approach can be applied through three of our own cases.

3 Hands-on with Practices and Limitations

As outlined above, our research emphasizes how students must understand digital technologies to critically reflect on their implications. In this section, we will demonstrate how we, in our own research and design activities, have given students hands-on experiences with the practices and limitations of digital technologies to have students reflect on the implications of their own practices when they design and build with digital technologies. And how the issues and challenges students run into in these activities can help them 'decode' [12] real-world technologies.

3.1 ML-Machine: Machine learning as a design material

ML-machine [7] is an educational tool for exploring data-driven practices for building ML models and these models' abilities to identify patterns in data. Through embodied interaction, students build their own small ML systems and test how these systems perform and are received by their peers. In this design process, students must deal with the limitations of ML in the form of unintended biases that sneak into their datasets and misrepresentations in their data sampling. These hands-on experiences can be used to reflect on the limitations of real-world ML systems and how the benefits of these systems must be weighed against issues with biases and misrepresentations.

3.2 The Engine Room: Hands-on with text generation algorithms

The Engine Room (see https://maskinrummet.github.io/#/en) is a suite of activities aiming to give students hands-on experiences with how text becomes data and how new text is generated from this data. Students engage directly with simple algorithms for text classification and generation by making and editing simple datasets of sentences. These activities look to foreground LLMs as constrained mathematical systems working probabilistically, allowing children to explore basic principles of model behavior

through the production and iteration of their own training data and adjustment of simple model parameters. In our submission [2] to this year's IDC conference, we demonstrate how the activities support critical reflections among first language students about how computers and humans make sense of text and literature.

3.3 Datafy: Students designing their own recommendation system

Datafy is an educational tool under development that aims to introduce children to basic elements of data literacy, specifically collecting, analyzing, and using data to create digital artifacts. Students engage with data about music and their peers' music preferences to design their own recommendation systems, which recommend music to different individuals and occasions. The tool enables a hands-on peek into the structure of recommendation algorithms by allowing children to perform data filtering and visual analysis of the various data properties. By grounding the activity in music, a context that is very personal to most children, the tool allows the children to directly engage with their interests through subjective data collection on their own favourite songs. This personal approach frequently produces undesired results and frustrations to the students, highlighting the role and scope of data in recommendation systems.

The cases demonstrate different levels of simplification where specifically chosen elements of a digital technology are exposed. The challenges in choosing an appropriate level of simplification is a foundational discussion in computational thinking [26], and we believe CE should also engage in this discussion, or at least have its own discussion about it. With goals and values different from CT, CE may want to expose different aspects of and practices around digital technologies. We argue CE tools should focus on exposing the design questions in developing and deploying digital technologies (e.g., design questions for developing machine learning systems: [3]) as these questions involve the value judgments and trade-offs that define who should benefit from digital technologies.

4 Empowering Children to Make Sustainable Changes

In this position paper, we have argued for a pragmatic approach to CE and demonstrated how we have explored this approach in our own research. Digital systems only become more complicated to discuss in terms of trade-offs; to teach the underlying technologies of; and to simplify without oversimplifying. We believe the CE community must discuss the implications of this and ask what it pragmatically requires to sustain and take agency in a world where digital technologies are developed and integrated at the speed we currently experience. In the EU and the US, we currently see a political climate where many actively take critical stances towards existing political and societal structures. But this political engagement has limited sustainable impact, because it is uninstitutionalized, case-driven, and volatile [18], partly due to the fast speed of the digital technologies we consume and their ever-changing algorithmic focus. This demonstrates the challenge of turning critical engagement into transformative agency and questions whether we need more critical individuals or stronger communities to act through. We ask how CE can support students in engaging with the complexities of our digitized societies and use digital technologies to make sustainable changes together.

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Thinking with Theory of Planned Behavior: How do Different UX and Social Factors Shape Chinese Children's Brand Perceptions and Digital Behaviors?

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Abstract

This position paper explains the motivation for our research in Chinese children's digital behavior. We propose the Theory of Planned Behavior (TPB) as a powerful conceptual framework for studying and empowering children's digital behaviors, with a specific focus on brand engagement in culturally diverse contexts. We argue that TPB—through its components of attitude, subjective norms, and perceived behavioral control—offers a robust lens to examine how user experience (UX) design, social influence, and accessibility affect children's intentions and actions in digital environments. Anchored in a post-qualitative inquiry and informed by contextual casework in China, this study advocates for treating children not as passive data sources but as co-constructors of digital meaning. We highlight the significance of cultural factors, especially parental mediation, and educational environments, in shaping digital brand interactions. By foregrounding China's unique digital ecosystem and Confucian cultural values, we outline a cross-cultural research agenda aimed at refining TPB-informed models to better study children's digital literacy and brand perception. This work invites further theoretical exploration of how children's digital behavior can be researched through post-human, culturally aware, and behaviorally informed research approaches.

Keywords

User Experience (UX), Theory of Planned Behavior (TPB), Childrens' digital Engagement, Chinese Children, Chinese Parenting, Digital Branding, Children's brand recognition, Post-Human-Design, Post-Qualitative Methodology, Digital Media Interaction

1 Introduction

The digital world is an essential part of children's daily lives, especially for those aged 8-12. As digital natives, these children are not only interacting with technology but are also engaging with brands in ways that will shape their future consumption patterns and

digital identities (Chaudron, 2017). Understanding how children engage with digital content, brands, and platforms is critical for empowering them as informed, responsible digital citizens.

However, there remains a significant gap in theory-driven, cross-cultural research on children's digital brand experiences. Much of the existing research focuses on isolated cultural contexts (Stoilova, 2016), neglecting the diversity of digital behaviors across regions. Furthermore, much of the research lacks a robust theoretical framework that can predict and guide children's behavior and engagement with digital brands.

This study addresses this gap by using Theory of Planned Behavior (TPB) (Ajzen, 1991) to study children's digital brand experiences in China. We argue that the TPB provides a compelling framework to empower children digitally, especially when studying their attitude, social norms, perceived behavioral control in the context of engaging with brand digitally. TPB offers a structured way to understand how user experience (UX) and social factors such as parents and peers impact their digital behaviors. By exploring this framework in cross-cultural contexts, we can pave the way for more inclusive and effective digital empowerment strategies for children.

Furthermore, to add value from a cultural perspective, China is a good choice for its unique digital ecosystem, characterized by the dominance of digital platforms like WeChat, Douyin, and social media-driven brand engagement, provides a distinct environment for children's digital experiences (Zhou, 2024). Unlike Western counterparts, where children's brand perceptions may be shaped more independently, Chinese children's interactions are often embedded within parental mediation and educational settings, making Chinese children worth investigating (Zhou, 2024).

For an empirical study, we suggest adopting a post-qualitative inquiry approach (Romm, 2020), treating knowledge as relationally and contextually co-constructed through interactions between children, the researcher, and digital environments. Specifically, we give an example of analyzing how on LEGO's social media through their digital UX factors contribute to brand perception and loyalty. Thus, our study addresses the following research question: "How do different UX and social factors shape Chinese children's brand perceptions and digital behaviors?"

2 Theoretical Position

The Theory of Planned Behavior (TPB) (Ajzen, 1991) illustrates factors that explain why humans have certain plans for their behavior. By "thinking with TPB", we offer new hypotheses developed through data and insights from our interviews, case study and experiment, observation with Chinese children in Shanghai. The objective is to "Think with theory" and data (Jackson and Mazzei, 2013) to explain Chinese children's planned digital behaviors, particularly in the context of brand engagement.

We explore key aspects of children's digital behavior, focusing on factors such as their internal attitudes and perception (attitudes); external control (perceived behavioral control); as well as the social-cultural factors (social norms). Specifically, within the digital branding space, we investigate the materiality of children's engagement behaviors through a case study and experiment with LEGO's social media.

Our research supports thinking with TPB to create a conceptual framework where digital brand engagement behavior is performed through key materialities, which we develop as follows:

- Attitude (children's personal preferences and perceptions–with a focus on UX)
- Social Norms (peer and parental influences)
- Perceived Behavioral Control (accessibility, usability, and restrictions)
- Intention (children's motivation to engage with digital content)

We are not the first to use TPB to study interaction design with children. Previously, TPB has been suggested as useful to promote healthy behaviors for young adolescents (Bec, 2012). For making changes, the TPB has been used for application design of a mobile system to motivate teenagers' physical activity (Arteaga, Kudeki, Woodworth, & Kurniawan, 2010; Ma, Veldhuis, Bekker, Hu, & Vos, 2019). Additionally, TPB has been used to examine whether adults who know the children well intend to support the future use of a novel multisensory participatory design for children with special educational needs and disabilities (Robb, Leahy, Sung, & Goodman, 2017).

3 Contextual Position – Why China

Children's digital experiences are not shaped in the same way across different areas in the world. In China, unique cultural values like Confucianism and strong parental influence shape children's digital experiences differently from Western countries (Cao, Dong, & Li, 2024). Confucian values emphasize respect for elders, discipline, and education (Shek & Yu, 2013). Compared to children in Western cultures, Chinese children are more likely to follow their parents' and teachers' opinions (Zhou, 2024). They trust authority figures and are more open to brands recommended by parents, teachers, or celebrities they admire (Cao, Dong, & Li, 2022). Because of this cultural influence, many Chinese digital platforms focus on structured and guided experiences, such as educational apps approved by schools (Dong, Cao, & Li, 2020). Furthermore, digital learning platforms are controlled by parents (Liu & Xu, 2023). In China, for instance, the educational environment, regional differences, and the dominance of unique national platforms like WeChat and Douyin (Chinese TikTok) that differ from their Western counterparts, suggests a different materiality for children's engagement with the digital world. Starting with a focus on the Chinese context, we believe that our study will provide valuable insights on how children's digital engagement should be studied with socio-cultural perspective, empowering future researchers to design better strategies for studying children worldwide.

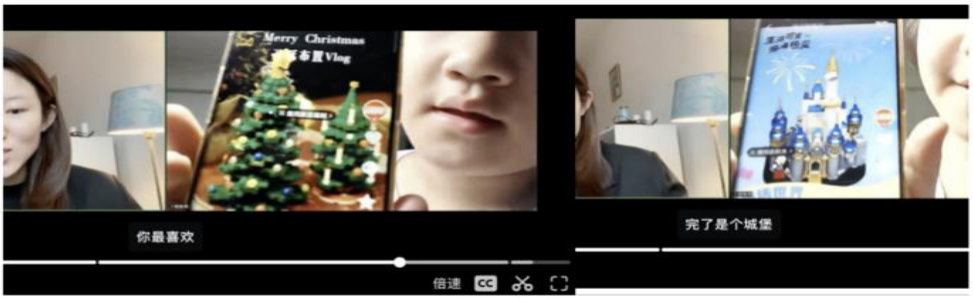

Figure 1: During the interview, the children showed their preference for LEGO Douyin video content. Link to the interview: https://meeting.tencent.com/cw/NbWm7gj546(It is 18:21 and 18:59 that shows the screen capture)

4 Developing a Post-Qualitative Approach–Thinking with TPB

Our research attempts to develop a post-qualitative approach, learning from Romm's (2020) performative and intra-active research paradigm to generate knowledge about how Chinese children engage with digital content and co-construct perceptions of brand value and meaning. Rather than treating children as subjects whose attitudes and behaviors can be measured or predicted or interpreted, this study adopted the idea that research is an ongoing, relational process, in which insights are generated through interaction and in the context (Romm, 2020). Participants are understood not as data sources, but as co-inquirers who shape the direction and aim of the research.

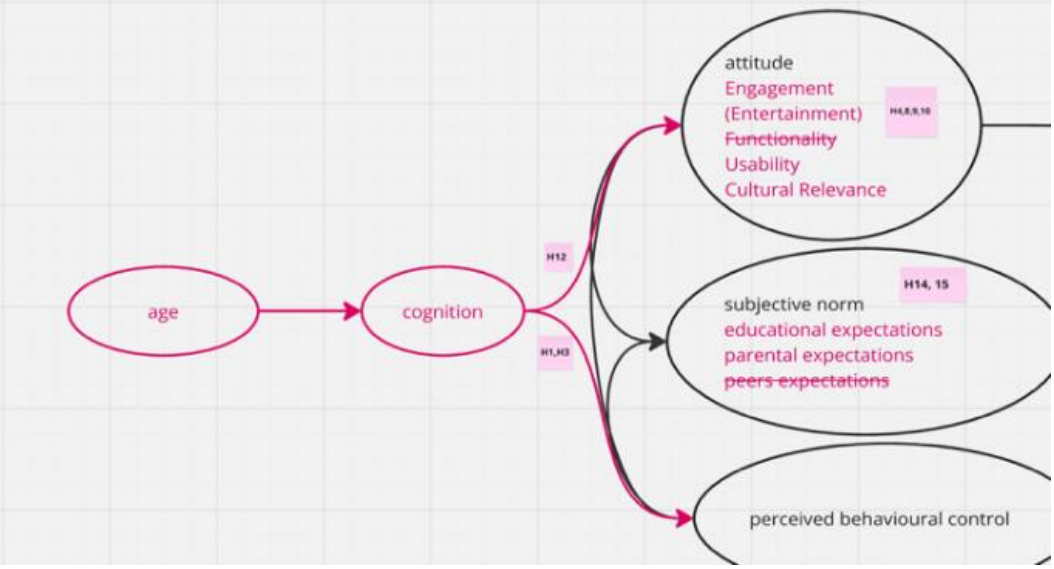

Figure 2: Thinking with TPB within the context: Attitude is shaped by age-related content preferences

For example, after viewing LEGO's Douyin account, Child T (8 years old) mentioned their preference for themes like the Christmas tree and castle, which suggests that visually appealing and imaginative themes are important to brand recognition, see Fig 1 and Fig 2. Rather than using TPB to measure or even interpret existing researcher-collected data, Fig. 1 and 2 reposition brand perception and TPB as something new. Inspired by Romm (2020), this research sees post-qualitative knowledge generations as deeply connected to both ethics and ways of knowing—where interviews, digital tasks, and conversations are not just tools, but part of the knowledge construction process. This study invites children to reflect on and respond to selected brand experiences (e.g., LEGO's mini-program or social media platforms), not to extract their "true opinions," but to collaboratively uncover how meaning is created in the digital environments.

Thus, the research value is that, rather than attempting to provide a fully predictive model, this research develops hypotheses that can serve as a foundation for future studies. While this work gets inspiration from the Theory of Planned Behavior (TPB), it does not use TPB as a strict and predictive model. Instead, TPB's key constructs—attitudes, perceived behavioral control, and subjective norms—serve as conceptual anchors for structuring exploratory discussions. The aim is not to predict behavior using the TPB, but to develop new hypotheses about how children's digital experiences relate to the materialities of culture, age, social factors, external environment etc.

5 Further Post-Qualitative Insights

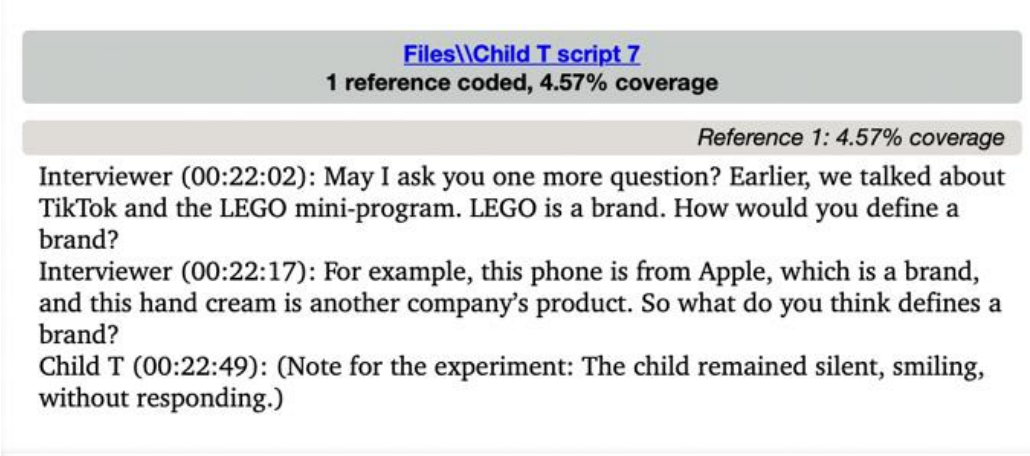

Figure 3: An example segment of coded interview in NVivo. This segment shows Child T's silent response to the question regard brand definition

One of the insights from our research is that children's understanding of brands is not a fixed "stage" but a relational becoming—shaped by their intra-actions with language, silence, content shown, environmental inspirations, the person they interact with, etc. Child W, 10 years old, when the interviewer asked about her definition of brands, admitted, *"I don't really know"*, while Child T, 8 years old, remained smiling silently after being prompted many times. While Child M, 12 years old, stated, *"It's a big, famous label"*. Child X, 11 years old, explained, *"It's like... a group of similar things that have a name or brand on them. For example, if I have a pen and it's a Pilot pen, or if I have a book and it's from the Pilot brand"*. The child's brand recognition (e.g., 12-year-old Child M saying *"a big, famous label"*) is not merely an outcome of 'internal psychology and age' factors but is co-created by the shoes they wear, the pen they hold, and the digital devices present during the interview. Even though this could only explain Child M's response, it is an intra-active process that develops the result. Thus, brand knowledge creation happens through these post-human intra-actions, not only as cognitive and age-related stages, which showcases how post-qualitative is challenging the existing research methods.

6 Discussion

Our research aims to develop new theory based on "thinking with Theory of Planned Behavior" (Ajzen, 1991). Post-qualitative methodology is adopted to explore how Chinese children engage with digital content and co-construct perceptions of brand value and meaning. Our study offers new inspiration for understanding and empowering children's digital experiences, especially in the context of brand engagement. By engaging children aged 8-12 and relevant theoretical and cultural contexts, we create insights on how the materialities of children's attitudes towards digital media, external social influences, and perceived control shape their digital behavior within a branding context.

With this position paper that builds on a LEGO case, we take up the provocation to shift toward researching and developing methods to enable children to participate in design activities that align with industry timelines (Sim, 2025). This research agenda has the potential to bridge the gap between theory and practice, offering practical insights for

researchers, educators, and marketers who wish to create a more positive and empowering digital environment for children. We invite feedback and collaboration from the academic and industry communities to further refine and explore these ideas, working together to develop what we take as a flexible and post-human approach for children-related studies.

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From Control to Digital Co-Agency: Reimagining Child Online Ethical Safety

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Abstract

This paper argues that current child online safety tools overemphasize parental control and surveillance, undermining trust and failing to build children's protective capacities. We frame this as a self-regulation challenge: safety systems should scaffold children's reflective judgment over time. Drawing on child–computer interaction, digital parenting, and AI ethics, we reframe child online safety as a socio-technical dilemma. We introduce **digital co-agency**" to describe collaborative, personalized, and autonomy-enhancing approaches that treat children as active participants in shaping their digital lives. To operationalize this digital co-agency, we specify **ethical safety** imperatives: autonomy-enhancing protection, privacy-by-design, and explainable, contestable mechanisms. The paper outlines the key shifts needed in participatory design, explainable safety systems, and multi-stakeholder collaboration to move toward a personalized, rights-respecting, context-sensitive, culturally responsive, and resilience-building safety ecosystem.

Keywords

Child online safety, digital co-agency, ethical safety, parental mediation, explainable AI, participatory design, socio-technical systems

1. The Protection Paradox in Child Online Safety

The more we try to protect children online through restrictive tools, the less we equip them with the digital literacy and self-regulation skills they need. The current ecosystem of parental control apps operates on a model of control, promising peace of mind through features like web filtering, screen time limits, and monitoring (Gnanasekaran & De Moor, 2025). Similarly, recent legislation like the UK's Online Safety Act (Parliament of the United Kingdom, 2023) and the EU's Digital Services Act (European Parliament & Council of the European Union, 2022) often defaults to these control-based mechanisms.

Restrictive mediation can reduce online risks but often at the cost of limiting digital inclusion and opportunities to learn independent protective behaviors (Livingstone et al., 2017; Livingstone, 2019). Excessive monitoring can transform family dynamics into a framework of surveillance, eroding trust (Hertog et al., 2024). Crucially, children can

bypass controls, pushing activity into less visible channels (Stoilova et al., 2023). These systems accordingly raise several ethical concerns, such as:

- **Data privacy:** Some apps exhibit weak safeguards and risky data-handling (Zuboff, 2019).
- **Algorithmic bias:** Automated moderation can amplify social biases, harming marginalized groups (Noble, 2018).
- **Transparency:** Families are given little explanation or recourse when content is blocked (Hertog et al., 2024; Stoilova et al., 2023).
- **Positionality:** Optimization for majority norms can marginalize minority experiences, termed the “violence of the majority” (Hendawy, 2025).

The exclusion of children from design processes further complicates this dilemma reinforcing top-down governance, leading to mistrust and avoidance (Atabey et al., 2025; Özkul et al., 2025). Addressing this requires grounding design in Self-Regulated Learning (SRL). SRL provides a theoretical mechanism for shifting from external control to internal capacity-building. Safety tools should scaffold SRL cycles—forethought, performance, self-reflection—to amplify "teachable moments" rather than just trigger restriction (Long, 2017; Stephens, 2024).

2. Child Online Safety as a Socio-Technical Dilemma

Child online safety is a socio-technical problem. Failures stem from discrepancies between technical design and social objectives like fostering autonomy (Baxter & Sommerville, 2011). Similar dynamics have been identified across AI governance domains, where systems designed “for” users systematically reduce their role to compliance rather than participation, a process described by Hendawy et al. (2025) as digital passivization. This reframing aligns with recent theoretical work arguing that agency is distributed across humans, non-humans, and digital infrastructures, such that responsibility cannot be coherently individualized (Rubino, 2026). To counter this, safety interventions must be anchored in SRL, transforming risky moments into teachable ones. To counter this, safety interventions must be anchored in Self-Regulated Learning (SRL), transforming risky moments into teachable moments.

Treating this as a socio-technical dilemma changes our approach. Instead of asking, “How do we block harmful content?” we ask harder questions: (1) Who defines “safety” and for whom?; (2) What values are embedded in safety tools?; (3) How are children’s rights and voices respected?; (4) How do cultural and economic contexts shape safety? These questions demand interdisciplinary insights across fields: social and behavioral sciences, communication and media studies, education and pedagogy, public health and child protection, legal and human rights, technology and design, political economy, and justice and equity frameworks (Table 1).

To operationalize the socio-technical ecosystem illustrated in Table 1, we anchor safety interventions in Self-Regulated Learning (SRL). While traditional controls reduce children to passive subjects, an SRL-based design focuses on building children’s cognitive and emotional regulation skills. By scaffolding SRL cycles (forethought, performance, self-reflection), technology can transform "risky moments" into "teachable moments" that foster metacognition rather than defaulting to external restriction.

Table 1 - Interdisciplinary Domains and Examples of Key Considerations for a Socio-Technical Approach to Child Online Safety.

Domain	Example of the Key Considerations for Child Online Safety
1. Social & Behavioural Sciences	Developmental psychology, family dynamics, sociology of childhood.
2. Communication & Media Studies	Platform economies, online cultures, mis/disinformation.
3. Education & Pedagogy	Critical digital literacy, self-regulation, metacognition, resilience scaffolding, and educational technology.
4. Public Health & Child Protection	Safeguarding frameworks, mental health impacts, and preventative care.
5. Legal, Governance & Human Rights	Data protection (GDPR), children's rights (UNCRC), and accountability.
6. Technology, Cybersecurity & Design	HCI, child-computer interaction, AI safety, secure-by-design.
7. Systemic & Political-Economic	Surveillance capitalism, platform governance, digital inequality.
8. Justice & Equity	Algorithmic bias, distributive justice, and recognition of marginalized groups.

3. The Shift to Co-Agency and Ethical Safety

We conceptualize digital co-agency as a paradigm where safety is a shared practice distributed across children, caregivers, and AI systems, grounded in the normative boundaries of ethical safety and the psychological mechanism of Self-Regulated Learning (SRL).

Digital co-agency reframes safety from an outcome of unilateral control to a shared, relational practice (Livingstone & Helsper, 2008). Rather than viewing technology as a top-down enforcer, it reconceptualizes AI as a mediating instrument that facilitates dialogue, negotiation, and learning—directly engaging the social dimensions of trust, communication, and evolving norms (Baxter & Sommerville, 2011; Takeuchi & Stevens, 2011). This relational paradigm resonates with broader theoretical efforts to reconceptualize agency and responsibility beyond liberal individualist frameworks (Rubino, 2026). Empirical work in HCI has likewise shown how family-mediated support functions as a form of digital co-agency, particularly for marginalized users navigating complex technological and political infrastructures (Ghadamighalandari et al., 2025).

To be effective, digital co-agency must be grounded in a clear normative standard: **ethical safety.** Protection is legitimate only when it is rights-respecting and developmentally supportive (see UN Committee on the Rights of the Child, 2021). Ethical safety requires systems to be autonomy-respecting (scaffolding self-regulation rather than suppressing it (see Deci & Ryan, 2000; Zimmerman, 2002), privacy-preserving (rejecting routine surveillance for negotiated monitoring (see Nissenbaum, 2009), learning-oriented (treating risk as teachable moments (see Vygotsky, 1978)), and contestable (ensuring decisions are explainable and challengeable (see (Mittelstadt et al., 2016).

Collectively, these principles shift child online safety across three levels: from minimizing risk to maximizing autonomy (normative shift in safety goal), from surveillance to negotiated privacy (mediational shift in family practice), and from black-box restriction to contestable safety (systemic shift in technology design)—defining the operational requirements for implementing the Digital Co-agency (see Figure 1).

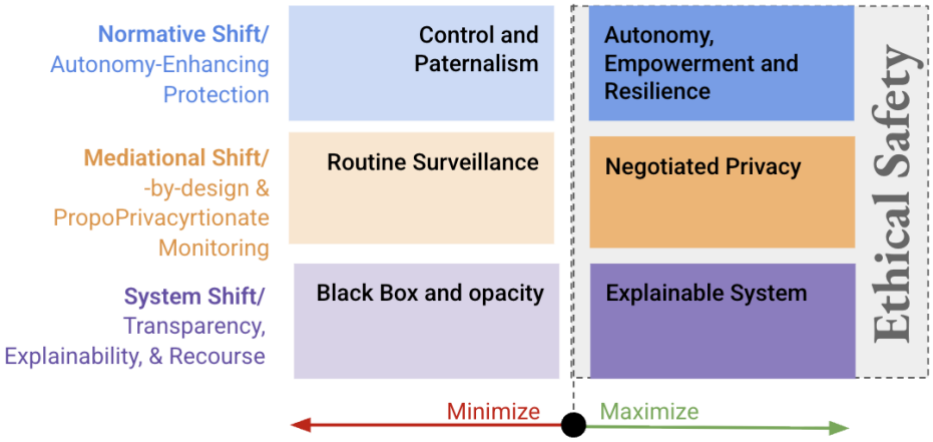

Figure 1. A Digital Co-Agency Approach to Child Online Safety. The three shifts—normative, mediational, and systemic—move from paternalistic control toward autonomy-respecting, privacy-preserving, and contestable systems, all grounded in ethical safety.

4. Practical Implications: Justice and Cultural Responsiveness

Operationalizing co-agency reshapes "good safety" around participatory, intergenerational design that treats children as legitimate stakeholders (Guha et al., 2013; UN Committee on the Rights of the Child, 2021), independent oversight beyond industry self-regulation (European Commission, 2025), and an explicit justice lens. Safety tools are unevenly distributed across families, shaped by inequality, culture, and digital divides (Chaudron et al., 2018; Hendawy, 2024). AI systems optimizing for majority data sideline minority experiences (Hendawy, 2025), a risk amplified by generative AI (Hendawy, 2024). Ethical safety thus becomes the mechanism for implementing co-agency: protection strengthens children as capable digital citizens rather than passive subjects of surveillance.

A justice-oriented approach requires context-sensitive systems responsive to culture, family norms, and socioeconomic conditions (Chaudron et al., 2018; Hendawy, 2024). This implies three commitments:

- **Cultural responsiveness:** Safety is not universal. What counts as "risk" and "autonomy" varies across cultures (Chaudron et al., 2018). Tools must be flexible rather than imposing one-size-fits-all models.
- **Personalization without surveillance:** Personalization should mean context-sensitive developmental support, not increased data extraction or monitoring.
- **Ethical guardrails:** Culturally responsive personalization requires participatory input, privacy-preserving design, and contestable decisions to

prevent reproducing bias or normalizing surveillance (Chaudron et al., 2018; Hendawy, 2024).

Developing culturally responsive, autonomy-supporting safety systems requires participatory design, privacy-preserving practices, and explainable, contestable mechanisms. Given the socio-technical nature of child online safety, coordinated changes in research, design, and governance are needed—there is no single fix.

5. Challenges and Limitations

While the digital co-agency approach offers a path toward more ethical and resilient safety systems, several socio-technical challenges complicate its implementation. First, a digital literacy gap leaves many caregivers feeling ill-equipped to engage in negotiated privacy, often defaulting to restrictive apps due to fear or perceived digital inferiority (Livingstone et al., 2017; Modecki et al., 2022). Research on digitally marginalized populations demonstrates that family-mediated support is not merely helpful but often essential for navigating complex technological and political barriers (Ghadamighalandari et al., 2025). Safety tools must therefore support parental literacy alongside children's (Digital Cooperation Organization, 2024). Second, developmental calibration is critical: the balance between protection and autonomy differs across ages (Vigdal & Brønnick, 2022). For younger children, co-agency requires robust, scaffolded protection with gradual opportunities for reflection, while for teenagers it must prioritize autonomy and privacy, as heavy restriction backfires by undermining trust (Chaudron et al., 2018; Boyd, 2014). Third, for severe risks such as grooming or child sexual abuse material, non-negotiable automated safeguards remain necessary; the challenge lies in implementing these without normalizing covert surveillance for lesser risks (Deldari et al., 2024). Finally, conflicting commercial incentives pose a structural barrier. Surveillance-capitalist business models prioritize engagement over privacy and autonomy (Zuboff, 2019), yet co-agency requires reflective pauses that conflict with engagement-optimizing design. Privacy-by-design also reduces harvestable data, weakening voluntary adoption. Viable implementation thus requires independent oversight and enforceable governance rather than industry self-regulation alone (OECD, 2021).

6. Conclusions and Future Work

Current control-oriented tools create a "protection paradox," eroding trust and self-regulation. We must transition toward digital co-agency—a paradigm we introduce that grounds ethical safety in a shared practice that empowers children. This approach operationalizes this transformation through autonomy-respecting, privacy-preserving, learning-oriented, and contestable safety systems. Realizing this vision requires intergenerational co-design, enforceable governance frameworks, and a sustained focus on digital resilience. Future work must empirically evaluate co-agentic tools across diverse cultural settings to move from conceptual promise to grounded practice.

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Facilitating and Evaluating Computational Empowerment: Integrating Dialogic Learning and Formative Assessment in Pedagogical Practices and EdTech Design

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Abstract

To push the boundaries of Computational Empowerment (CE), research must address critical gaps in assessment and educational sustainability. This paper proposes a synergistic approach integrating dialogic learning and formative assessment to bridge the disconnect between CE concepts and pedagogical practice. By combining dialogic learning's focus on non-hierarchical, critical exchange with formative assessment's emphasis on ongoing feedback and agency, we explore this synergistic approach that is aligned with CE's goal of transformative agency. Preliminary research from two projects: KIMDORIT (AI literacy education) and Datafy (critical data literacy tools) indicates that dialogic formative assessment may foster deeper critical reflection, empower learner agency, and support learning within complex CE contexts. Therefore, we argue that embedding dialogic formative assessment into both pedagogical strategies and EdTech design creates a synergy that makes CE assessable, impactful, and sustainable, offering a vital pathway for future research.

Keywords

Computational Empowerment, Formative Assessment, Dialogic Learning

1 Introduction

To push the boundaries of computational empowerment, we must explore how to assess and facilitate computational empowerment across educational contexts. Integrating dialogic learning and formative assessment is a novel approach with significant potential to address the current gap in computational empowerment research: assessment of CE and long-term sustainability in educational contexts (Göbl et al.,

2023; Van Mechelen et al., 2021, 2023). Dialogic learning focuses on how learning occurs through dialogues between two equals instead of in a hierarchical manner, promoting critical thinking, flexibility, adaptation, creativity and innovation (Manalo, 2020). Formative assessment focuses on supporting learners through developing knowledge and self-regulated learning to reach the learning goal, encouraging learners to develop agency (Black & Wiliam, 1998). Dialogic learning and formative assessment are intertwined in concepts and highly relevant to CE's focus on promoting critical engagement with technology and children's agency. Exploring how these two can be combined as a novel approach could address the gaps in pedagogical practices and assessment frameworks for CE in K-12 computing education (Van Mechelen et al., 2021, 2023). Since CE is an interdisciplinary research area of computing education and emerging technology development, we should explore how the combination of dialogic learning and formative assessment could be applied and contribute to not only pedagogical practices but also EdTech development, and how these silos can work together as synergy to reach its best potential to push the boundaries of CE across educational contexts.

2 Background

As society becomes increasingly digitized through rapid technological advancements, education systems are challenged to cultivate not just technical proficiency but also critical, reflective and empowered engagement with technology. In response to this challenge, Iversen, Smith and Dindler (Iversen et al., 2018) introduced the concept of Computational Empowerment (CE) to K-12 computing education by integrating Participatory Design (PD) approaches. CE seeks to foster children's agency and digital citizenship by encouraging their reflective and critical interaction with digital and emerging technologies (Van Mechelen et al., 2023). Central to CE is the belief that empowerment arises from learners participating in both the construction and deconstruction of technology (Dindler et al., 2022). CE has been discussed from multiple perspectives within CCI research, such as relevance to K-12 education (Dindler et al., 2020), implications in teaching and learning (Göbl et al., 2023; Schaper et al., 2022), relationship with computational thinking and computer science education (Iversen et al., 2018; Lachney & Yadav, 2023; Musaeus et al., 2022; Odgaard, 2023), its progression and future research directions (Kaspersen et al., 2021; Smith et al., 2024), and its connections to play (Tikkanen et al., 2023), social justice (Iivari, Ventä-Olkkonen, Hartikainen, Sharma, Lehto, & Holappa, 2023), critical thinking (Morales-Navarro et al., 2022; Tissenbaum et al., 2017), and broader societal impact (Iivari, Ventä-Olkkonen, Hartikainen, Sharma, Lehto, Holappa, et al., 2023).

Despite the growing body of CE research, assessment of CE remains a significant gap. A lack of educator involvement in CE research has led to a disconnect between pedagogical practice and CE concepts, hindering broader adoption and sustainability across educational contexts (Van Mechelen et al., 2021, 2023). Therefore, there is an urgent need to develop a meaningful assessment framework to address this gap. As such, we propose an integrative approach combining dialogic learning perspectives and formative assessment principles, which will be elaborated on their connection to CE as follows.

3 A Synergistic Approach: Formative Assessment and Dialogic Learning

Formative assessment aims at support learning toward intended learning outcomes through activities where teachers and students exchange feedback to adjust their teaching and learning approaches (Boston, 2002). These activities and feedback opportunities occur mainly through ongoing dialogues between learners, peers and teachers (Wiliam, 2018). It emphasizes student agency, collaboration, critical reflection and adaptive learning, all of which resonate strongly with CE's principles (Liu et al., 2025). In this context, formative assessment is not merely a method of evaluation but an ongoing process where students engage in dialogues about their learning, enabling ongoing reflection and adjustment (Boston, 2002). Such process enhances learners' metacognition and encourages them to take ownership of their development, aligning closely with CE's emphasis on empowerment through critical technology engagement.

Dialogic learning as a pedagogical approach essentially means that learning occurs through dialogues between equal participants rather than through hierarchical exchanges. This dialogic approach posits that learners' knowledge construction requires dialogic interaction with peers, teachers, and tools. This principle complements formative assessment's perspectives on dialogues and reflection, offering a holistic pedagogical framework that supports the development of CE in K-12 Education. Several key intersections emerge:

First, both formative assessment and dialogic learning highlight that learners should take ownership and responsibility for their learning (Manalo, 2020; Wiliam, 2018). This aligns well with CE's goal to foster children's agency and digital citizenship in relation to technology and to prioritize their role as an active participant in the learning process as a pathway for empowerment.

Second, both approaches see learning as a continuous, ongoing, and evolving process, supporting CE's notion of transformative agency. Dialogic learning posits that learners' construction of knowledge through dialogues is never final and is open to flexibility, adaptation, and creativity and innovation (Manalo, 2020). On the other hand, formative assessment can be designed within teaching units, across teaching units, or across years (Wiliam, 2018). This ongoing approach is aligned well with CE's notion of transformative agency, where students move from awareness, acquiring knowledge, to taking actions within an indefinite period of time (Iivari et al., 2024).

Moreover, both emphasize the importance of collaboration, feedback and interaction between peers and teachers (Wegerif, 2007; Wiliam, 2018). Furthermore, in dialogic learning, textbooks can be seen as agents in the dialogic interaction as they contribute to the knowledge construction (Wegerif, 2007). This offers a powerful reframe for CE: interaction with digital tools is not passive but could be viewed as a dialogical process between two equals, as users construct meaning and technical understanding through interaction with the tools and technology.

Finally, dialogic learning emphasizes that learning occurs in the interaction between equal partners and can be enhanced through attributing less authority to the information given (Linden & Renshaw, 2004). This notion of equality and authority-questioning resonates with CE's focus on deconstructing technology systems by challenging the

authority of these systems and computational outputs like data and AI, and critically examining their impact on individuals and communities, thereby empowering learners to engage in democratic participation within digital environments.

In conclusion, as CE activities and initiatives mostly involve learning activities and technology tools, we propose that this integrative approach of dialogic learning and formative assessment should be applied and considered in both pedagogical practices and EdTech design. This integration offers a pathway to developing assessments that are both pedagogically sound and aligned with CE's transformative goals.

4 Preliminary Research

The following projects explore how the combination of dialogic learning and formative assessment could be applied and contribute to both pedagogical practices and EdTech development.

4.1 Dialogic Formative Assessment Embedded in AI Literacy Learning Activities: KIMDORIT

In the KIMDORIT project, we facilitated co-design workshops with K-9 teachers in Denmark, providing the necessary supports to design learning experiences that teach AI literacy (Casal-Otero et al., 2023) and embed formative assessment, and emphasize dialogic learning. During the workshops, we introduced the LLM teaching tool Maskinrummet (Connelly, 2024), explained the technical concepts behind it, and presented both the pedagogical CE framework – the DORIT model (Dindler et al., 2023) – and the principles of embedded formative assessment.

Throughout the workshops, teachers collaboratively developed lesson plans and designed formative assessment opportunities tailored to their classroom. These designs were grounded in their professional expertise and inspired by the ideas and tools shared during the workshops. Following the planning phase, the teachers developed corresponding teaching materials and implemented them in their classrooms. During these implementations, we conducted observations and collected field notes, focused on formative assessment practices and dialogic learning.

Preliminary findings indicate that teachers significantly rely on students' dialogic expressions as a means to assess students' understanding and to adapt instructional strategies in real time. These dialogues not only deepened students' learning but also created opportunities for critical and reflective thinking, core values within CE's concept. However, meaningfully achieving reflective and critical thinking proved challenging without a foundational understanding of the underlying technical concepts. The cognitive demands for understanding technical concepts are significant and time-consuming. Thus, typical instructional timeframes pose time constraints that challenge to fully grasp these concepts and limit the depth of reflective thinking. Further research could push CE boundaries by exploring how dialogic formative assessment approaches might better bridge technical content and reflective thinking. By doing so, it may be possible to alleviate cognitive load and create more effective pathways for integrating complex technical knowledge into meaningful classroom dialogue.

4.2 Dialogic Formative Assessment Embedded into the EdTech Development for Critical Data Literacies: Datafy

In the Datafy project, we explored how the principles of dialogic formative assessment could be integrated into the development process of educational technology tools aimed at teaching children critical data literacies (Pangrazio & Selwyn, 2023). This collaborative design initiative brought together a multidisciplinary team, including in-service teachers and researchers with expertise in computer science and learning sciences. In addition to addressing the core subject matter of critical data literacy, the project placed emphasis on embedding formative assessment practices and creating opportunities for dialogic learning. We designed the prototype with concreate learning activities in mind. The result was a prototype designed to enable primary school children to use Micro:bit (BBC & The Micro:bit Educational Foundation, 2025) to produce data on the music they like, interpret and analyze this data to curate playlists for specific contexts, and collaborate with peers throughout the learning process (Figure 1).

Figure 1: Students connect Micro:bit to the web-based prototype and dance while holding Micro:bit to collect data.

The prototype was tested in a primary school in Denmark with two teachers and 40 pupils. Insights from dialogic formative assessment informed the design in several ways to promote CE learning opportunities. First, since most users tend to view computed data as authoritative truth (Tseng & Fogg, 1999), clearly communicating the potential inaccuracies inherent in Micro:bit's data production helps to challenge this assumption and decenter the perceived authority away from the computed data. This aligns with dialogic learning perspectives to decenter authority to children in order to provoke questioning, reflection, and engagement in critical dialogue about the data and its meaning. Second, the prototype documents each step of the learning process with the tool. This supports a low stakes learning process, where trial and error is viewed as a natural and valuable part of the learning process. Moreover, this documentation supports analysis and argumentation, allowing students to trace and articulate their reasoning. Third, the prototype highlights collaborative, learner-centered design. By encouraging students to collect personally meaningful data, such as music they enjoy, the prototype fosters intrinsic motivation and contextual relevance. The hands-on, collaborative approach invites shared exploration and peer dialogue, reinforcing a child-centered learning experience.

Our key takeaway from the testing is the importance of designing with learning activities in mind. Features that require extensive written response do not necessarily prompt students' deep engagement or critical thinking. In contrast, features that provoke

dialogic inquiry and discussion serve as effective catalyst for critical reflection, deeper reasoning, and argumentation, central aims of CE. Further research could explore how to extend these design suggestions and break the silos between pedagogical practices and EdTech development.

5 Conclusion & Call to Action

In conclusion, we advocate for a synergistic approach that combines dialogic learning and formative assessment to inform both CE pedagogical practices and tool design. We argue that to make CE more impactful and sustainable requires an intentional synergy of pedagogical practices and educational technology design. Embedding dialogic formative assessment into both domains offers significant potential to foster deeper critical reflection, empower learner agency, and support learning within complex CE contexts. This approach provides valuable opportunities to elicit and respond to learning evidence. These arguments align closely with the workshops' themes of impact and sustainability, aimed to contribute both practical and conceptual insights on how dialogic formative assessment can be adapted and applied across various CE initiatives. For the future research in the field, we seek to raise two questions for collective exploration: (1) *how can dialogic formative assessment connect technical computing concepts with reflective, critical aspects of CE?* and (2) *how might we extend these principles into the design of educational tools in ways that promote sustainable CE learning and adoption?*

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Supporting Young Children's Computational Empowerment through Problem Framing

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Abstract

Many Child-Computer Interaction (CCI) research prioritises children's participation in the design process to inform design outcomes that might impact their lives. This position paper introduces Storying-Roleplay, a co-design method that supports young children's Computational Empowerment by fostering early problem framing skills. The method involves eliciting children's personal stories, creating characters, designing tangible probes and engaging in roleplay to collaboratively reframe complex problem space. We worked with children aged 4-5 years to explore their perspectives on environmental

problems. Our approach emphasizes relational and systems thinking, enhancing children's input in the early stages of design process. Through this method, children's thinking shifted from absolutist to more relational and reflexive perspectives. We argue that by supporting young children's agency in problem framing, Storying-Roleplay lays foundation for meaningful engagement with social and ecological dimensions of technology designs for them. This work contributes to CCI by offering a developmentally appropriate pathway toward early Computational Empowerment.

Keywords

Child computer interaction, Codesign, Problem framing, Computational empowerment, Environmental sustainability

1 Introduction

The future of today's young generation will be shaped by both emerging technologies and an escalating environmental crisis. Consequently, a recent work has called for designing technologies, integrating children's positive experiences of nature engagement and negative consequences of environmental crisis to enable children to understand and cope constructively with the ever-growing concerns of climate change [2, 13]. Within this context, CCI community is increasingly focused on fostering children's agency to critically participate in technology design process [5, 8]. This approach empowers children by valuing their perspectives, resulting in designs that are not only effective for them but also foster a sense of ownership and responsibility towards the design outcome. In doing so, design research with children tends to focus on developing a design outcome, often asking children to express their ideas and needs. However, less attention has been paid to young children's (under six years old) needs and context of use [12]. This trend is also reported in a recent systematic review on co-designing nature engagement technologies with children, which highlights the underrepresentation of younger age group [14]. In response, our research explored how children aged 4-5 years might contribute to framing design problems, developing an initial understanding of environmental problems (early stage of design process), so they develop the skills to understand the problem space itself.

We present *Storying-Roleplay* [10], an iterative co-design method that evolved children's thinking from absolutist and oppositional views to thinking through interdependence and cause-effect relationships. This shift fostered greater agency and enhanced their participation in the design process. We position this Storying-Roleplay as a co-design method under the umbrella of Computational Empowerment [4, 9]. This framing aligns with the approaches to Computational Empowerment that emphasize on increasing children participation and agency, particularly scaffolding matters related to digital technology and its effects on the society [7]. We argue that fostering and early understanding of contextual problem spaces and the interconnectedness nature of ecosystems is critical for developing reflexive awareness children need to understand how digital technologies shape their lives and society at large.

This paper positions that Computational Empowerment can be supported through relational co-design methods, such as Storying-Roleplay, that help children make sense of complex and interconnected problem space before engaging in the later stages of co-designing technologies. Our method supports this process through children's active

participation in eliciting stories, creating characters and roleplaying. This approach fosters early systems thinking and problem framing, laying the foundational skills for more meaningful forms of Computational Empowerment later in the design.

2 Connecting Storying-Roleplay to Computational Empowerment

Our Storying-Roleplay approach is grounded in the principles of Participatory Design (PD), which positions children as capable contributors in shaping meaningful technologies for their future [5, 12]. Within this method, children engage in eliciting stories that are personally relevant and socially meaningful. Through these narratives, they create characters that they use in roleplay, enhancing their agency and allowing them to share their voices in the ethical and political dimensions of technology design. While our focus has been on using this method to explore the problem space of environmental sustainability, we see its potential in helping children make sense of a wide range of complex problems including those related to children's computational interactions. As such the method offers a way for children to reflect on and understand how technology affects their lives and lives of others. This resonates with the resent calls to scaffold children's Computational Empowerment by not just empowering children through technical proficiency, but also to analyse and reflect on how technology affects their lives and others [4, 6, 7]. Storying-Roleplay, therefore, contributes not only to the field of PD but also helps define what early Computational Empowerment looks like, as a holistic, participatory and imaginative process through children's lived experiences and acknowledging their capabilities to think, care and take others' perspectives.

Our focus on supporting children to understand the problem space; why the problem exists in the first place, helped them consider the complexities of relationships and interdependencies. By understanding the roles of multi-stakeholders and the contextual factors, even young children were able to grasp the more complex genesis of problems (e.g. environmental problem). Problem framing, in this way, becomes an essential element of problem setting as in reflective practices [11]. This reflective thinking skill, considering the ecosystem as an interconnected whole, has the potential to develop interdisciplinary skills. Thus, CCI researchers are well positioned to further investigate problem framing as a design space to support children's Computational Empowerment.

3 Engaging with Emerging Technologies

We see Storying-Roleplay as a developmentally appropriate method for young children with potential to create conceptual and meaningful foundations for engaging with emerging technologies and complex issues. Rather than beginning with technological solutions, our approach takes a step back, empowering children to explore tensions, relationships and perspective taking before introducing technological solutions. This method embeds children's play-based learning approaches [1] that offer children a safe space and familiar space to express their ideas and preferences. Additionally, as co-creators of stories and characters, children become familiar with the iterative thinking and relational ethics which are foundational for participatory and inclusive designs practices of emerging technologies [3].

In our study, we designed a butterfly garden probe (Figure 1) with which children expressed their understanding of the relationship between different species (e.g. butterfly, plants, humans) within a garden ecosystem. This probe served both as a design artefact and learning scaffold, offering a basic guideline for designing tangible technologies with young children from scratch. With this, our work contributes to the field of CCI in co-designing relational technologies; technologies that support understanding of ecosystems and interdependence.

Figure 1: Butterfly garden probe designed with children through Storying-Roleplay approach

This process of probe design aligns with productive collaboration [15], focusing on creating an environment for children to be aware of the roles other stakeholders play. This emphasizes on perspective taking and understanding cause-effect relationships that complements Computational Empowerment for children. We envision integrating Storying-Roleplay into the design of emerging relational technologies such as Internet of Things or Conversational AI. In these contexts, the method can support children in developing a deeper understanding of the systems they are part of, fostering not just technical engagement but through critical, ethical and reflective participation.

4 Conclusion

In this paper, we introduced Storying-Roleplay as a relational co-design method that supports young children in understanding complex and interconnected problem spaces, laying the groundwork for Computational Empowerment. Grounded in PD research, this method offers a pathway for fostering such capabilities in young children by leveraging children's play instincts through storytelling, character creation and roleplay. As we look to push the boundaries of Computational Empowerment, our study demonstrates how young children can meaningfully contribute to problem framing, developing an early systems thinking and perspective taking skills. We invite researchers and educators to embrace the value of contextual understanding and formulating problem space before trying to solve the problems with technological designs. As emerging technologies become increasingly embedded in daily lives,

methods such as Storying-Roleplay offer valuable pathways for inclusive, reflective and empowering technology design with and for children, allowing children to raise questions about the effects of technology designs in their lives and the society at large.

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Personally Relevant Everyday Computational Empowerment for the Mobile-first Children in the Indian Context

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Abstract

This work advances the discourse on Computational Empowerment (CE) by foregrounding the experiences of underrepresented students in India, many of whom have limited personal devices or login access, highlighting a unique technological landscape. Within this context, we seek to extend CE as "Everyday Computational Empowerment", a profoundly personal democratic view of empowerment relevant to the everyday lived experiences of these young learners in the computational world that surrounds them. Designing technologies, applications, and learning experiences for empowerment must consider these contextual constraints. To this end, we advocate for mobile-first, low-barrier entry points that focus on children's self-view and world-view and their competence in everyday interactions, empowering new generations to understand digital technology and its consequences for individuals, communities, and society at large, thereby enabling a more inclusive and context-sensitive approach to CE.

Keywords

Computational Empowerment, Computational Thinking, Global South

1 Introduction

Computational Empowerment (CE), as originally conceptualized by researchers such as Iversen et al. (2018) and Dindler et al. (2020), extends beyond teaching programming or digital skills to emphasize the importance of individuals being able to construct and critically deconstruct technology in ways that are socially impactful [3, 6]. Their work argues for shifting learners from passive users to active shapers of digital systems, embedding empowerment within both computational fluency and critical agency [20].

This perspective is further deepened in the growing body of work around critical Computational Empowerment (Critical CE) and critical framings of re-evaluating computational thinking (CT), which seeks to investigate the sociopolitical dimensions of technology associated with the skillsets of CT. Research in this area includes practices such as algorithm auditing and examining the biases embedded in data and systems, encouraging learners not only to build technologies but also to question their implications and power dynamics [8, 10, 19]. This critical lens positions computational thinking as a tool for equity, agency, and justice, rather than as a neutral skill set.

Researchers such as Tissenbaum et al. (2017) have furthered the scope of Critical CE with computational identity (CI) into computing education. They emphasise the importance of contextually grounded computing that allows learners to express themselves and build applications to solve real-world issues, with low-barrier-to-entry design platforms such as MIT App Inventor [18]. Similar research on designing constructionist computing environments fosters critical design practices, where young learners participate in creating not only technologies but also e-textiles and media content to reflect on technologies in relation to their communities and lived experiences [7, 9]. While these approaches emerge from different theoretical backgrounds, they converge in their alignment with functional, educational, and critical views of empowerment [11], aiming to equip learners with the capacity to act meaningfully and to cast an impact on computing designs and power dynamics worldwide.

Schulte and Budde (2018) have discussed the goal of fostering mature, self-determined participation by individuals to prevent people from being controlled by technology. In their Hybrid Interaction Systems (HIS) Framework, education is understood as the transformation of self-perception and world-perception through interactions. They emphasise the dual transformative nature of human–computer interactions, wherein individuals not only shape and modify computing systems but also undergo transformation themselves—in their views, behaviours, and modes of interaction through the very act of engaging with these systems [15]. There remains a pressing need to extend these ideas into a vision of democratic empowerment in the world of ubiquitous computing, one that supports both children and adults as equals while enabling them to take charge of such transformations through everyday interactions with technology. Additionally, there is a need to envision democratic views of CE and transformative agency for individuals utilising ubiquitous computing and digital technologies in everyday lives.

We position our views of "Everyday Computational Empowerment (ECE)" as a form of agency wherein individuals see themselves not as subordinate to technology, but as capable of engaging with, adapting to, and questioning the ubiquitous computing systems that increasingly permeate everyday life. ECE's position about democratic views of empowerment enables individuals, particularly young learners, to relate to the computational world as equals, reclaiming their position as active agents rather than passive users within it. This conceptualisation is rooted in a constructivist ontology, where learners develop a sense of empowerment by experiencing interactions with ubiquitous computing technologies. While it does not adopt a strictly relational worldview, it acknowledges technology as a social actor among many, interacting with human intentions, behaviours, and social contexts. Within this framework, empowerment emerges not in designing technology but in developing the competence

to navigate, adapt to, and critically engage with it, asserting agency rather than being controlled by it.

In contexts where access to technology is limited, it is essential to create safe and supportive spaces where learners can engage meaningfully with computational tools. In the following section, we elaborate on a specific underrepresented context: urban Indian children from low to middle-income families, whose primary engagement with ubiquitous computing occurs predominantly through shared access to smartphone devices.

2 About the Learners

This research focuses on urban Indian children from low- to middle-income families who, despite limited personal access to laptops or individual logins, regularly engage with mobile technologies through shared devices owned by parents or relatives [14, 16, 21]. Their screen time, primarily for entertainment or education, ranges from 30 minutes to four hours daily. These learners typically study under state-supported SSC boards, where computing education is minimal, limited to basic Windows OS tasks on shared lab computers. While a few high-performing students may access Scratch or programming workshops in summer camps, most lack such opportunities.

Given the pervasiveness of computing in daily life, it is crucial to equip these learners for democratic empowerment, encouraging them to become active, critical, and responsible users of technology. However, existing CE and Critical CE frameworks, developed in more resource-rich contexts, cannot be directly applied here due to access and contextual differences. We draw on recent calls to rearticulate CE to support transformative agency in digital societies with a shift from technocentric to socio-technical perspectives [5]. In response, the ECE approach extends CE into the mobile-first realities of these learners, aligned with their everyday lived experiences.

3 Background

The concept of ECE draws from the Bildung tradition, which emphasises personal growth, self-formation, and socially responsible agency [13, 17]. Rather than treating CT as a set of cognitive skills, ECE highlights CE in informal, situated interactions with technology. It supports subjectification, where learners develop critical agency and a sense of self in the computational world [1, 15]. This is especially crucial for learners in underrepresented, resource-constrained contexts to become active, reflective participants in the digital society, informed by their own views and aspirations. This framing aligns with Iivari's (2020) holistic view of digital empowerment—one that includes critical reflection, identity, and transformation of socio-technical systems [4]. Similarly, Mäkinen (2006) describes empowerment as evolving from personal confidence to collective societal impact [12]. We position ECE along this continuum, as a context-sensitive pathway toward democratic empowerment, rooted in everyday experience and growing into critical, socially engaged participation.

4 Ongoing Research and Proposed Future

Our ongoing research is along two interconnected directions aimed at deepening the understanding of Everyday Computational Empowerment (ECE) and its role in fostering computational empowerment in the Indian context. A literature review was

first conducted to explore the concepts of empowerment and literacies within computing education. Building on this review, a framework for ECE has been developed. The key dimensions of ECE were further refined through a Delphi study, in alignment with the Bildung paradigm's components of self-view, world-view, and habits of interaction [2, 13, 15]. Within the self-view dimension, we include aspects of empowerment, such as perceptions of self-efficacy, a sense of belonging, and perceived ability to impact the computational world. The world-view dimension captures learners' sense of connectedness to the computational world, reflecting their recognition that these systems are relevant and influential in their daily lives. Finally, the habits of interaction dimension encompasses varying levels of competence, ranging from recognising computational aspects in everyday contexts to understanding underlying mechanisms, making practical, meaningful use of existing technological systems, and being critically aware of their constraints and ill effects. This work is inspired by Iivari (2020)'s model of digital empowerment, particularly its focus on critical reflection, belongingness, and self-determination in relation to technology.

The second line of inquiry involves an empirical study with middle-school learners in India, focusing on their lived experiences and engagements with computational practices in everyday settings. We have designed a minimal-intervention playground 'AuthentiCT' for the learners to interact with technologies (e.g., AI voice agents like Alexa, smart home objects such as smart bulbs), which we use as a safe and guided engagement strategy to interact with the computational world. The study examines how learners interact with shared mobile devices, how they exercise agency in their interactions, and how these interactions reflect emerging dimensions of ECE. We observed middle-school students in India interacting with voice-based AI systems similar to Alexa in the AuthentiCT environment. Three illustrative cases highlight the dimensions of ECE observed.

1. A group of students (Group A) with soft voices initially struggled to make Alexa respond due to ambient noise and the device's inability to detect their speech. However, rather than withdrawing from the activity, the learners experimented with alternative strategies and discovered that they could input typed commands to create routines. This adaptation reflects an emerging self-efficacy and practical utility competence, which are crucial for enabling learners to persist and participate meaningfully in technological interactions.

2. In one instance, although learners (Group B) raised their voices, the device still failed to respond. They began rehearsing and rewriting their sentences in English, using notepads to refine pronunciation and sentence structure. When asked why, one learner remarked, *"Because Alexa is USA, right?"*- a simple yet insightful reflection on the cultural and linguistic biases in technology. Such moments show learners moving beyond adaptation to critical questioning, recognising that these technologies may not be designed with their context in mind. This critical awareness and agency are central to the democratic CE that ECE seeks to foster

3. In another instance, learners (Group C) noticed that Alexa responded even when other groups issued commands, prompting a realisation that the device was continuously listening. This sparked a moment of critical awareness: an understanding of the pervasive and sometimes invisible nature of technology.

> Though not yet designing technologies, these learners are developing the critical awareness to question and navigate computing systems, a powerful form of digital and computational empowerment. With supportive education, such early insights can grow into both computational fluency and civic agency.

The authors acknowledge that this form of empowerment focuses on individuals' everyday experiences and does not yet address broader societal goals of CE and Critical CE, or systemic issues like governance and infrastructure. However, the mobile-first research approach prioritises individuals' firsthand engagement with ubiquitous computing as a foundational step toward democratic views of empowerment. ECE thus emphasises both computational competence and the development of a meaningful worldview within the computational landscape.

Looking ahead, our future work will focus on refining and validating the identified dimensions of ECE through qualitative studies that examine how these dimensions manifest across diverse socio-cultural and technological contexts. This work will serve as a foundation for designing inclusive educational interventions that resonate with learners' everyday experiences and foster democratic empowerment. We are currently in the analysis phase of the recent AuthentiCT study, and we aim to document and share our findings to contribute meaningfully to the growing body of research on CE, particularly within underrepresented and contextually similar communities.

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Supporting Criticality in Computational Empowerment

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Abstract

Recently, CCI has introduced the research agenda of Computational Empowerment (CE), which aims to move young people's learning about technology beyond mere technical skill teaching towards their capacity to analyze, critique, and transform these technologies that recursively influence their lives. However, constructionist educational practices, in which students learn by building artifacts that are meaningful to them, often utilized by scholars investigating CE, hold technosolutionist tendencies. In this position paper, we reflect on our practices that aim to disrupt this technosolutionism (values, speculation, and critical making) and point to questions we still have. We center critical pedagogy as one avenue for this transformation, yet we believe that more attention should be given to its cognitive and affective dimensions. Particularly, we observed that cultivating criticality requires that learners have space for dissent. To name and legitimize this mode of engagement, we propose the *design rebel* as a novel learner role that foregrounds refusal, subversion, play, and oppositional creativity as valid forms of participation within CE.

Keywords

Computational Empowerment, Critical Pedagogy, Critical Literacy, Values, Speculative Design, Critical Making, Metacognition, Design rebel

1 Introduction

This work originates from a position statement submitted to the "*Pushing the Boundaries of Computational Empowerment of Children*" workshop at the ACM Interaction Design and Children Conference 2025 (IDC 2025). In that position statement we argued for the importance of critical pedagogy within K-12 education to support Computational Empowerment (CE) (Dindler et al., 2020), understood as enabling children to recognize, contest, and reshape the technological systems that

recursively configure their lives. We particularly emphasized value negotiation, and speculative thinking, and critical making among young learners as pedagogical resources for advancing criticality, and called for pedagogical approaches that move beyond functional or skills-based framings of computing. At the same time, we recognized the need for further investigation into how to support students' cognitive foundations for criticality in CE and into practical implementations of Critical Literacy (CL) for CE that can be taken up within formal and informal learning environments. In this writing, we extend our earlier position by clarifying what we mean by criticality, identifying questions that remain to be addressed, and presenting a possible new role for children in design research: the *design rebel*. The considerations we present draw on our collaborative empirical work and reflective discussions over the past three years.

2 Moving construction beyond technosolutionism through criticality

Building on Iversen et al.'s (2017) concept of the child as design protagonist, our work incorporates constructionist (Harel and Papert, 1991) pedagogies to support children's CE in formal and informal education. Constructionism emphasizes learning through building personally meaningful artifacts. The Child-Computer Interaction (CCI) community has recognized its potential for critical engagement with technology (Dindler et al., 2020; Kafai and Resnick, 2012; Morales-Navarro and Kafai, 2023). However, without a critical lens, constructionist approaches such as design and making risk perpetuating technosolutionism and anthropocentric modernist ideologies (Durall Gazulla et al., 2025; Kinnula et al., 2022; Stables, 2017). To address this, we have been exploring approaches to embed criticality within constructionist practices, drawing from CCI (Dindler et al., 2020; Iivari and Kuutti, 2018; Iversen et al., 2017), the learning sciences (Lewison et al., 2002; Luke, 2012; Spendlove, 2017; Stables, 2017), and critical design methodologies (Auger, 2013; Dunne and Raby, 2024, 2021; Friedman and Hendry, 2019; Ratto, 2011).

2.1 What do we mean when we say criticality?

When discussing criticality in the context of CE, we distinguish between related but conceptually different notions: critical thinking and critiquing, reflection and critical reflection. While these terms are often used interchangeably in educational discourse, treating them as synonyms obscures the depth of engagement required for learners to meaningfully interrogate and reshape technological systems.

Critical thinking, in its conventional formulation, typically focuses on logical reasoning, evaluation of evidence, identification of assumptions, and problem-solving (Sternberg, 1986). It is often framed as a cognitive skillset enabling students to make sound judgments within a given situation (Ennis, 1989). While important, critical thinking alone tends to operate within existing conceptual and ideological boundaries (Luke, 2012). **Critiquing**, by contrast, foregrounds interpretive, evaluative, and normative stances. It involves examining how artifacts, practices, or systems embody particular values, assumptions, and worldviews of dominant groups (Luke, 2012); it asks not only "*is this effective?*" but "*for whom, and according to which norms?*" In this sense, critique is not merely an intellectual act but a sociopolitical one, attending to, among others, power, representation, and the distribution of benefits and harms (Butler, 2002; Foucault, 1996). Drawing from traditions in critical theory (Horkheimer, 1972), we thus

understand critique, not as neutral assessment, but an immanent and systemic, emancipatory practice that interrogates how knowledge and power organize social life and subjectivity.

A similar distinction can be made between reflection and critical reflection. Reflection, as commonly practiced in design and education, centers on personal experience: what went well, what could be improved, what was learned (Baykal et al., 2021; Bekker et al., 2015; Schön, 1983). We see **critical reflection**, a term often discussed in CCI literature (Antle et al., 2021; Iivari et al., 2024a; Murai et al., 2022), as extending beyond individual introspection or technical problem-solving to examine the broader socio-material and political conditions that shape those experiences (Habermas, 1971). Rather than asking, "*What did I experience and why?*", critical reflection invites learners to ask, "*How are my experiences shaped by power relations, cultural narratives, institutional arrangements, and technological infrastructures and what might it mean to challenge or reconfigure them?*" In this sense, critical reflection positions learners not only as analysts of their own processes but as agents capable of questioning and unsettling dominant narratives.

2.2 Intertwining critical literacy with computational empowerment

This critical perspective orients young people's technology education from a focus on technical proficiency to a sociotechnical understanding of how technical systems are entangled with humans, politics, economy, culture, history, ideology, the planet, and power. In line with other CCI scholars (Iivari et al., 2024b; Velander et al., 2024), our prior work has highlighted **critical literacy** (CL) as a promising avenue for supporting children's and youths' CE in relation to emerging technologies (Veldhuis et al., 2025b). CL encourages learners to analyze, question, critique, and transform the information they encounter, fostering nuanced understandings of the sociological, cultural, political, and ethical dimensions of technologies (Freire, 1970). Through CL, learners can move from passively accepting technological environments to recognizing their social and political implications (Freire, 1970, p. 9). Without such orientation, technology education risks reproducing technocratic ideologies that treat social problems as purely technical and privilege narrow forms of expertise (Postman, 2011).

Although critical pedagogy has been applied across primary and secondary education (Vasquez, 2014; Lewison et al., 2002), its translation into technology education remains tenuous. The absence of clearly articulated learning goals limits its uptake within formal curricula (Velander et al., 2024). To provide such structure, Lewison et al. (2002) synthesized CL into four interlinked dimensions: (1) *disrupting the commonplace* by reframing everyday perspectives, (2) *considering multiple viewpoints* through engagement with diverse perspectives, (3) *focusing on the sociopolitical* by examining power relations and technological systems, and (4) *taking action* by applying theory to practice. Extending this framework toward CE requires pedagogical approaches that can concretely support these dimensions.

2.3 Making critical literacy actionable through design practices

We draw on CL's articulation of critique and Praxis. Butler (2002) casts critique not simply as a method but as a virtue and ongoing practice, an orientation toward questioning the norms and conditions that shape social and technological life. Building

on Freire (1970)'s notions of *Praxis*, CL frames learning as a dialogical cycle of critical reflection and action in which learners confront systems of oppression, including technocapitalism, as historically situated and therefore open to transformation. Education becomes a practice of empowerment in which students actively imagine and enact alternatives. This understanding aligns with critical design traditions (Bardzell and Bardzell, 2013; Dunne and Raby, 2021) that use design artifacts and scenarios to expose taken-for-granted assumptions, unsettle normative technological imaginaries, and prompt reflection on alternative futures. The goal of critical design is not to solve problems efficiently but to problematize (Cambridge University Press, 2014), making visible the values, priorities, and worldviews embedded in technologies. When integrated into constructionist learning environments, such approaches can scaffold critique and critical reflection by encouraging learners to question not only how technologies function, but also why they are built the way they are, what futures they presuppose, and whose interests they serve. In this way, criticality can become a generative force that enables learners to imagine and construct new sociotechnical possibilities rather than merely evaluating existing ones.

2.4 Values

Values as a design lens can support learners' critical reflection on and engagement with emerging technologies (Bardzell and Bardzell, 2013). Although not a critical design approach itself, we draw on **value-sensitive design** (VSD) to integrate human values into educational design processes (Friedman and Hendry, 2019), thereby enhancing students' ability to consider multiple viewpoints when designing in educational contexts. In design research, values have been framed in ethical terms such as welfare and justice (Friedman, 1997) and later broadened to include what groups or individuals consider important in life (Friedman et al., 2006). Psychology offers a complementary lens, understanding values as enduring principles that guide judgments and behavior across contexts, ordered by relative importance (Schwartz and Bilsky, 1987). We adopt a pluralist view (Berlin, 1988) that treats values as diverse and often in tension, while maintaining that shared goods such as justice and equity are not to be relativized (Arendt, 1961). Following Van de Poel and Kudina (2022), we further take a pragmatist stance in which values function as experiential tools for identifying what is morally salient and for guiding action.

In prior works, focusing on values has enabled young learners to reflect on their own and others' beliefs (Elsayed-Ali et al., 2020; Schaper et al., 2022; Veldhuis et al., 2025a), to engage with and design for alternative value constellations (DiPaola et al., 2020; Kenny et al., 2025), and to consider the values their designs (are meant to) embody (Durall Gazulla et al., 2025, Iivari et al., 2024b). To further investigate VSD to support CE, we explored how to: (1) provide students with a value-based language to conceptualize and articulate values, (2) use value lenses to examine sociotechnical implications of emerging technologies, (3) scaffold the adoption of normative stances through value advocacy, (4) structure collaboration around ongoing value negotiation, and (5) sustain value reflection throughout design and making. Inspired by the notion of "designerly well-being" (Stables, 2014), education practices (Aronson, 1978; Eriksson et al., 2022), and the concept of "values advocates" (Manders-Huits and Zimmer, 2009), we developed a project series in which students (a) reflect on and implement personal and group values in design (Veldhuis et al., 2025a), (b) identify

values within their communities, and (c) explore value tensions by advocating for perspectives different from their own (Veldhuis et al., in review).

Building on these explorations, several questions emerged that point to the need for deeper inquiry into how values can meaningfully support CE through constructionist practice. First, it remains unclear how different ways of introducing values in projects, such as values that emerge from context, predefined values, or randomized values for perspective taking, shape students' opportunities for critical reflection. Second, sustaining value contestation over time proved difficult, since consensus pressures frequently diluted commitments and values often became vague or instrumental once scaffolding was reduced. Students also tended to abandon value-based intentions in favor of designs they perceived as more functional. These observations raise questions regarding how to support continued negotiation of values without reducing them to constraints, and how to assist learners in "staying with" (Haraway, 2020) their value commitments during making. Third, a further challenge concerns enabling students to use values to reason about micro, meso, and macro level implications of their designs. Learners require opportunities to consider how values are enacted through technological systems, and to examine their temporal, relational, and scalar variability across individuals, communities, institutions, societies, and ecologies. Fourth, although value advocacy encouraged principled commitments, fostering authentic personal advocacy within formal education remains challenging. Finally, there is a need to model how values can be integrated for different outcomes at all points of the process. Such models may clarify where value reflection is most generative and how it can be embedded within constructionist practices that seek to render critical literacy actionable for young learners

2.5 Speculation

Rooted in critical and feminist theories, **speculative design** offers young learners a way to challenge present and future issues by envisioning alternative possibilities (Dunne and Raby, 2024; Auger, 2013). Speculative design aims not to predict the future but to provoke reflection by challenging taken-for-granted assumptions, unsettling dominant sociotechnical narratives, and opening imaginaries toward more just possibilities. In contrast to functional framings of technological literacy, speculative design foregrounds inquiry into how technologies are entangled with social, cultural, political, and ecological systems rather than treating them as neutral tools.

In our work (Kenny et al., 2025), we employ speculative design techniques such as alternative present narratives and worldbuilding to help suspend hegemonic assumptions and position youth to critically interrogate how social life shapes technology development by situating emerging technology within alternative socio-cultural contexts, foregrounding value-laden decision-making, and supporting reasoning across micro, meso, and macro system levels. Here youth reimagined future city infrastructures allowing them to scrutinize the ways in which artificial intelligence (AI) is part of a larger and dynamic socio-technical assemblage and envision alternative future technologies that address community needs. Our work examined how these techniques can support learners in 1) scrutinizing the present, 2) resisting the status quo, and 3) experimenting with transformative imaginaries that move beyond deterministic or techno-solutionist tropes.

These explorations raise several questions that highlight opportunities for further research. First, learners often struggled to imagine beyond present-day constraints, even when invited into alternative contexts. Persistent attachments to feasibility, efficiency, and existing economic logics limited their capacity for radical reimagination (Fisher, 2022), suggesting a need for approaches that more intentionally cultivate imaginative freedom (Atkinson, 2025) and unsettle entrenched worldviews. Second, while learners demonstrated strong abilities to trace relational implications of AI across scales, they required sustained facilitation to address power and systemic forms of oppression, indicating that speculative design alone may not fully scaffold sociopolitical analysis for young learners. Third, integrating speculation within constructionist workflows poses methodological challenges: how to maintain imaginative openness while also supporting material making, and how to prevent speculative activities from collapsing into problem-solving tasks shaped by familiar technocratic norms. Finally, it remains unclear how speculative critique translates into students' perceived or actual capacity to act: whether speculative interventions foster transformative agency or remain at the level of imaginative exercise. Understanding how speculative design can meaningfully link critical reflection to Praxis in CE thus remains an important direction for ongoing work.

2.6 Critical making

Critical making provides a materially grounded approach for enabling learners to interrogate emerging technologies by linking constructionist design practices with critical reflection. Ratto (2011) conceptualizes critical making as a process in which building artifacts supports and extends sociotechnical critique, reconnecting lived experiences with conceptual analysis. It differentiates itself from other commonly operationalized constructionist approaches in CE, such as design-based learning (Schaper et al., 2022), in that it doesn't center (technological) problem-solving. Critical making has been adapted for youth contexts as a means to promote technical literacy that includes design ethics, allowing children to explore how technological decisions shape individual and societal well-being (Antle et al., 2022). In this framing, prototypes serve not as finished products but as tools for thinking: they materialize ideas, surface assumptions, and create opportunities for reflection through iterative cycles of design, testing, and dialogue.

In our online biowearables workshop, middle-school youth used a custom prototyping kit, underdetermined decision points, and ethics cards to examine how sensor-based wearables could influence developing senses of identity, autonomy, agency, and authenticity (Antle et al., 2022). Facilitated reflection during making supported learners in articulating potential negative impacts of their own design choices and connecting technical configurations to broader concerns about well-being. Similarly, we have operationalized value-sensitive critical making activities for generative AI, which allowed students to operationalize value commitments in the design of custom chatbots (Veldhuis et al., in review) and experience the unruly and fallible nature of generative AI. Across both these projects, material engagement with technologies prompted students to question why systems behave as they do, whose interests they serve, and how design decisions redistribute benefits and harms. Structured supports, such as ethics cards, reflective documentation, and peer audits, were essential for ensuring that critique remained active throughout the making process rather than relegated to initial ideation.

However, to ensure that students continue to engage critically while taking action during the creation process, we stress the importance of exploring more ways to facilitate critical reflection throughout making. Insights from our work that such reflection does not arise spontaneously but must be deliberately scaffolded through tools, prompts, and facilitation that link design decisions to their sociotechnical implications.

This points to several pressing questions. How can critical making support learners in distinguishing between technical knowledge, experiential knowledge, and sociopolitical knowledge when analyzing emerging technologies, so that they do not collapse into purely functional reasoning? How do different material forms of making, including physical prototyping, digital prototyping, and hybrid forms, shape learners' understandings of what technologies are and what forms of agency they exert? And what kinds of tools or prototyping kits best support learners in examining not only user-facing interfaces but also data flows, model behaviors, and institutional contexts, thereby making visible the otherwise opaque infrastructures through which power and values are enacted in technological systems?

3 Building foundations for criticality in constructionism

3.1 Cognitive foundations for criticality

In our previous work (Veldhuis et al., 2025b), we used Bloom's taxonomy (Anderson and Krathwohl, 2001) to analyze how existing literature supports children's CL regarding AI. While not common in critical pedagogy, this cognitive framework is valuable for recognizing learners' prior knowledge and capacities. However, our focus was limited to higher-order thinking skills, overlooking the foundational cognitive processes necessary for developing CL, raising questions about the essential knowledge, dispositions, and developmental factors for CL within DBL.

One direction we propose is **epistemic metacognitive knowledge**, which concerns how knowledge is constructed and evaluated across disciplines. encompassing beliefs about knowledge (e.g., whether it is fixed or evolving) and self-awareness of cognitive biases (Hofer, 2004). Spendlove (2017) highlights the role of metacognition in helping students recognize heuristic flaws, cognitive biases, and ethical considerations in design and technology education. For instance, a lesson on designing for a newly married couple exposed students to how cultural expectations shaped their decisions, prompting reflection on their epistemological fallibility. These insights reinforce the need for supporting epistemic metacognitive knowledge for CL in constructionism, as it equips learners with the base knowledge needed critically engage with personal biases in decision-making during design and making.

3.2 Affective foundations for criticality

Criticality rests not only on merely on knowledge or analytical skills, but also on affective and identity-based capacities that allow learners to situate themselves within broader sociotechnical systems (Zembylas, 2021). Shannon's (1995, p. 83) account of critical perspectives conceptualizes literacy as a means for understanding one's own history and culture, and recognizing the relationship between personal experience and structural conditions. Extending this to CE suggests that CE must move beyond the "decoding and coding" of technical systems to include reflection on the self and one's relationship to the technological infrastructures that mediate social life. Such affective

and identity work opens pathways for designerly well-being (Stables, 2014) and activist orientations (Iivari et al., 2024b) in which learners view technological engagement as a site for personal expression, pursuing justice, and participating in societal change.

Supporting these orientations within formal education is complex, since classroom structures continue to privilege compliance and assessment. Even critical pedagogies operate within institutional logics that limit space for dissent. Yet our empirical work shows that learners often articulate informed refusals (Benjamin, 2016) once they begin problematizing technologies. We understand these refusals as expressions of emerging critical agency rather than obstacles to learning. Feenberg's (2012) notion that technological rationality is a product of social choice suggests that such refusals are moments in which learners recognize technologies as contestable and open to appropriation or redirection. Moreover, learners at times advanced their critique through deliberately absurd or antagonistic concepts (Bloom, 2023) that functioned as counter-imaginaries (Kazansky and Milan, 2021). However, these propositions were rarely treated as serious candidates for implementation, revealing a persistent tension between institutional expectations of "feasible" or "appropriate" solutions and the critical, oppositional stances that students were beginning to develop.

To encourage these modes of engagement, we introduce the **design rebel** as a critical role for children within CCI. The design rebel describes learner practices that intentionally disrupt normative expectations of technological engagement through refusal, subversion, personal expression, parody, or creative misuse (e.g., Malpass (2013)). Rather than aiming to produce functional artifacts, the design rebel foregrounds antagonism as a legitimate design stance that reveals and contests embedded values and power relations. This contribution positions dissent not as deviation from educational goals but as a vital expression of computational empowerment, expanding the repertoire of (learner) roles beyond user, informant, designer, or protagonist (Druin, 1999; Iversen et al., 2017) to include not only the critic, but also the saboteur. Supporting the design rebel requires pedagogical structures that legitimate refusal, create space for play and oppositional creativity, and treat disruption as a catalyst for critical reflection and sociotechnical imagination.

4 Conclusion

Taken together, these commitments call for a renewed engagement with constructionist approaches that explicitly cultivate the foundations necessary for criticality in CE. Drawing from critical pedagogy and critical design, we sketched how constructionist learning environments might move beyond its technosolutionist tendencies by sustaining value contestation, scaffolding speculative and critical inquiry, and designing making activities that keep sociotechnical implications at the center. We argued that more attention must be given to the cognitive and affective resources that enable young learners to interrogate, transform, or resist the technological systems that shape their lives. In particular, we emphasized epistemic metacognition as a potential cognitive resource for recognizing biases and assumptions in design, and highlighted affective and identity-oriented dimensions of criticality that help learners situate themselves within broader structures of power and inequality.

Crucially, cultivating such criticality requires that learners have space for dissent in both formal and informal learning contexts. To name and legitimize these modes of

engagement, we proposed the design rebel as a novel learner role that foregrounds refusal, subversion, play, and oppositional creativity as valid forms of participation within CCI. In doing so, we hope to contribute to a broader reimagining of CE that treats children not only as competent makers or designers, but also as critics and rebels who can meaningfully participate in shaping more just sociotechnical futures.

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Reimagining Teacher Roles for Computational Empowerment. A Call to Action for Teacher Education

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Abstract

Fostering Computational Empowerment (CE) and, thus, students' protagonistic stances in digitality, critically depends on teachers' ability to adopt and balance multifaceted roles. However, there is a significant gap in implementing this in practice, especially in educating teachers accordingly. This position paper addresses this gap by outlining key indications and strategic directions based on previous literature. Priorities include curriculum reform to integrate CE, development of educational materials, targeted professional development, fostering Professional Learning Communities, informing policy, and applied research. These focused efforts are essential to equip educators for effective CE implementation.

Keywords

Computational Empowerment, Teacher Education, Formal Education, Teacher Roles

1 Introduction

The educational system needs to empower students to become competent users and reflective creators. Computational Empowerment (CE) represents a related approach that emphasizes looking beyond more than "just" technology usage. It signifies critically engaging with digital technologies: questioning their role, using them thoughtfully, and actively shaping their form and function (Iversen et al., 2018; Schaper et al., 2022). The design of corresponding learning environments allows students to take on the new role of protagonist (Iversen et al., 2017; Mahboob Kanafi et al., 2022; Weixelbraun et al., 2024): Instead of being shaped by digital content, they shape the content themselves. Yet, the concept of protagonistic students often fails due to the reality of everyday school life (Göbl et al., 2023). While CE aims to build digital literacy, traditional classes often still focus on user skills (Harapat & Knobelsdorf, 2023; Hubwieser et al., 2011). Fostering critical thinking, creativity, and participation is often hindered by time constraints, inadequate training, and limited resources, restricting process-oriented projects. Moreover, the traditional 'knowledge transmitter' role (Wilson, 2020) often overshadows the facilitative approach crucial to CE's student-centered learning (Ehlenz et al., 2023).

To explore how we can advance CE's sustainable and long-term impact across educational contexts, this position paper focuses on the significance of teachers' varying roles. We argue for promoting a shift in teachers' professional self-image and actions, enabling them to effectively support students' active and formative digital capacity. This paper proposes distinct teacher roles for CE and outlines how to anchor them in education through collaboration between research and practice.

2 Key Role(s) of the teacher

Participatory design research indicates that in settings involving adults and children, the respective roles depend on each other (Yip et al., 2017). Similarly, enabling significant student participation, like the protagonist role, demands corresponding teacher counterparts and thus an evolution of their professional identity. Here, the traditional "sage on the stage" (King, 1993) appears to be insufficient for the cultivation of critical reflection, creativity and the will to create, which are central to CE. However, this traditional style persists, particularly among out-of-field teachers lacking the specific pedagogical content knowledge and confidence required (Hobbs, 2013). This appears as a significant challenge given that many computing subjects in lower secondary grade across Europe are taught by non-specialists (Commission et al., 2022).

To foster CE in the classroom, new teaching skills and attitudes are needed. These competencies build on established concepts such as constructionism and project-based learning that inform facilitation of creative processes (Papert, 1980). CE adds further dimensions: holistic views of technology/design, strong learner agency, and critical reflection. To promote CE, teachers must be able to adopt diverse roles, oftentimes simultaneously. Synthesizing insights from literature, we propose the following, context-dependent roles:

- **(Meta-)Designers of Learning and Learning Environments** design stimulating and supportive learning landscapes (DiSalvo & DesPortes, 2017). They carefully plan and curate relevant tools, methods, and project ideas linked to students' lives, and balance structure with openness for self-determined learning. This includes anticipating challenges, planning scaffolding, and focusing assessment on process and competency development.
- **Learning and Design Facilitators** compared to designers, act primarily during lessons. They prioritize the individual and collaborative learning process over the final result (Thompson, 2015; Van Mechelen et al., 2021). Facilitators conduct classes in a way that promotes a safe, failure-positive environment to encourage active engagement, experimentation, and student responsibility. In this role, teachers observe progress closely, ask guiding questions, and provide targeted scaffolding and formative feedback to empower independent problem solving.
- **Co-Learners and Co-Creators** act as fellow learners, especially with new, unfamiliar technologies (Boeve-De Pauw et al., 2024). This role engages students in partnership dialogue, genuinely valuing their knowledge and ideas while modeling curiosity. Further, co-learners join students in exploring, researching, and co-creating without dominating and strive to make learning processes transparent for all.

- **Mediators between CE and Formal Education** function as a translator and negotiator, pragmatically bridging the potential tension between open, emancipatory CE goals and formal education's requirements (Bosch, 2022; Bosch et al., 2025). They create space for CE within often rigid school structures by carefully aligning activities with curricula, developing suitable assessment methods, and communicating as well as legitimizing the approach to colleagues, administration, and parents.

3 Teacher Education Pathways For Enabling Computational Empowerment

Empowering students through CE hinges on equipping teachers for these (new) roles. However, there is a significant discrepancy between what is needed and what is taught in current teacher education. Bridging this gap requires teacher education institutions to focus dedicated efforts on pre- and in-service teacher training:

First, engaging with policy makers and administration to foster supportive conditions is crucial. Although empowerment and awareness are already embedded in school curricula (Commission et al., 2022), their explicit consideration in the classroom remains challenging: We need to urgently address the related need for systemic change in order to ensure flexibility, resources (time, space, training), and curricular framing for cross-curricular CE, despite standardized testing pressures, while preparing educators for these realities.

Second, it is essential to recalibrate teacher training. CE principles, related pedagogies that promote agency and critical reflection, and design-based learning approaches should be deeply integrated into general and subject-specific didactics. Future teachers must be prepared for the complexities of fostering open, student-centered processes.

Third, the development of communities of practice to bridge the gap between theory and practice. This involves initiating, facilitating, and supporting working groups that bring together pre-service teachers, in-service teachers, teacher educators, and researchers. These communities foster dialogue, collaborative problem-solving, resource adaption, and sustained CE engagement. However, these collaborations can also be set up locally within or across schools as Professional Learning Communities (PLC) (Druin, 2002; Ni et al., 2023). From the formation of robust PLCs, repositories for sharing lesson plans, curriculum resources, and classroom implementation experiences often emerge (Falkner et al., 2018).

Fourth, the design, dissemination maintenance and evaluation of high quality, practice- and research-based teaching materials and resources is an important task. Research and teacher education institutes can take a leading role in the design, curation and dissemination of scalable, evidence-based resources supporting CE. These materials need to a) be developed for and with educational institutions, b) reflect the reality of classrooms and c) support teachers explicitly to take on new roles (e.g. by providing frameworks for meta-design or facilitating differentiated learning pathways). These resources support both pre- and in-service teachers who are looking for practical resources.

Finally, conducting applied research and ensuring transfer to educational practice is imperative. Research must address teachers' practical CE challenges (e.g., assessment, managing roles under constraint). Findings must translate into tangible improvements in teacher education and resources.

All of these points require a participatory, democratic approach that heeds teachers' experiences and needs. Only through extensive collaboration between researchers and practitioners can we address current challenges and successfully ensure an implementation of CE that is close to everyday realities.

4 Conclusion

CE ultimately depends on teachers who are equipped for evolving roles beyond traditional instruction. Overcoming systemic barriers requires teacher education to cultivate these facilitator, designer, co-learner, and mediator competencies. Through strategic curriculum changes, resource development, and collaborative professional learning, we can empower educators to effectively foster student agency and critical engagement in a complex digital world.

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