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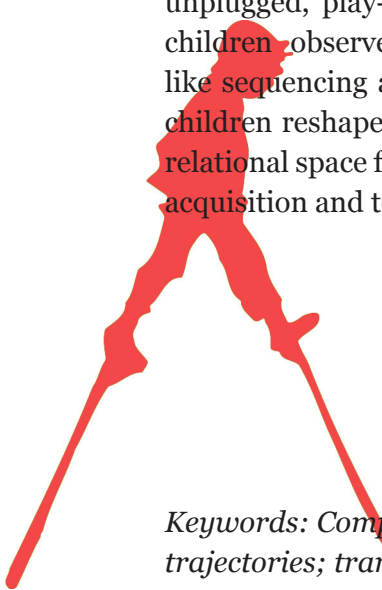
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Children's Transformative Agency in Computational Play – Imagine, Improvise and Influence

Abstract

This article explores how young children enact agency through computational play in a Danish kindergarten. Drawing on sociocultural theory, transformative agency, and participation trajectories, the study examines how children engage with computational thinking through unplugged, play-based activities. Using video and field ethnography, the study shows how children observe, improvise, and reconfigure tasks, embedding computational concepts like sequencing and decomposition in playful ways. Rather than following predefined goals, children reshape activities on their own terms. The study highlights computational play as a relational space for agency and co-exploration, expanding computational thinking beyond skill acquisition and toward imaginative, situated engagement.



Keywords: *Computational play; early childhood education; agency; participation trajectories; transformative agency; computational thinking*

Introduction

In recent years, Computational *Thinking* (CT) has gained increasing attention as a meaningful way to support children's learning and exploration across a variety of contexts (Bocconi et al., 2022; Angeli & Valanides, 2020; Bers, 2018). While CT is often associated with coding and digital technologies, it can also be understood as a way of thinking – a way children intuitively organize, structure, and solve problems in their everyday play and storytelling (Critten et al., 2022; Quinn et al., 2023).

Research shows that young children can develop foundational CT skills like sequencing, decomposition, and pattern recognition when they are allowed to engage with them on their own terms, through hands-on, unplugged and child-initiated activities (Brackmann et al., 2017; del Olmo-Muñoz et al., 2020). These practices rarely emerge through formal instruction alone but often evolve from children's own interests, through moments of curiosity, improvisation, repetition, and discovery. For example, a familiar storybook may introduce narrative sequencing, while building a LEGO bridge may prompt the exploration of spatial patterns and problem-solving strategies. In this way, CT lives within children's own practices long before it becomes a school subject (Bers, 2012; Scott et al., 2015).

In this study, we introduce the concept of computational play, describing computational play as a central element in fostering technological understanding in early childhood education. We use the concept to highlight how children's playful engagement with both digital and analogue materials can be seen as encounters with technology, encounters where questions of agency, power, and cultural meaning become visible. Computational play refers to hands-on, exploratory, and child-led engagements with CT concepts, where children interact with educators, peers, and materials to make sense of computational ideas in ways that are meaningful at their developmental level (Kaup et al., 2023). Rather than separating learning from play, computational play merges the two, supporting children's social, emotional, and cognitive development while enabling them to experiment, express ideas, and take an active part in shaping their digital future. This article takes a step in that direction by focusing on how children themselves use, shape, and even challenge computational logic as part of their play. While much previous research on CT in early childhood focused on adult-led instruction and pedagogical scaffolding, this article adopts the child's perspective.

To frame this inquiry, we draw on Lave and Wenger's (1991) theory of *legitimate peripheral participation*, as well as Karoff's (2011) elaboration of *trajectories of participation* and *sense of practice*. These perspectives allow us to explore how children's entry points into computational play are shaped by observation, repetition, disruption, and reconfiguration. In this context, *agency* is understood not as a fixed trait but as a relational and emergent capacity, expressed when children reposition themselves, negotiate rules, or introduce meanings into shared activities. By focusing on children's micro-movements between participation modes, the study offers insights into how agency is enacted through shifting forms of engagement. The study aims to answer the following research question:

How do children explore and express agency through their participation in computational play, and how do these movements reflect shifting trajectories of engagement and meaning-making?

Drawing on video and ethnographic data from a Danish kindergarten, this article analyses how children navigate structured activities and spontaneous play. It also analyses how their movement between involvement and distance, between order and chaos, becomes a way to explore and expand their agency when playing in computational activities. Rather than treating non-participation as absence, we show how children use peripheral positions to develop themselves at their own timing, rhythm, and criteria for participation. These movements are not just about learning to play, they are about negotiating meaning, shaping rules, and reclaiming control. In this sense, computational play becomes not only a matter of learning concepts, but of rehearsing power, the power to move between positions, to redefine activities, and to imagine otherwise.

Theory

Computational play enables children to explore technological understanding not through abstract instruction, but through concrete, hands-on engagements with materials, peers, and educators. These activities often unfold as cycles of curiosity, disruption, and reconfiguration. Kaup et al. (2025) describes this as a movement between *order and chaos*, where rules are tested, routines bent, and new meanings negotiated. This engages children in CT concepts such as algorithm design, abstraction, pattern recognition, and decomposition.

As part of this pedagogical framework, we draw on the principles of *read, learn, and play*: educators introduce a theme through storytelling (*read*), frame an activity linked to a CT concept (*learn*), and then open the space for children's creative experimentation (*play*). This approach supports both educators' scaffolding practices and children's trajectories of participation and agency in computational activities (Kaup et al., 2025). Computational play thus becomes a relational process in which CT is not only taught but lived and reshaped by children.

Children's agency in computational play

In this study, we approach children's agency as a situated, relational, and emerging phenomenon, shaped through social, material, and pedagogical conditions (Varelas et al., 2015). This view aligns with research in early childhood education that emphasizes children's right to participate, imagine, and contribute meaningfully to shared activities (Kultti et al., 2016; Pramling Samuelsson & Asplund Carlsson, 2008). Rather than treating agency as an innate individual trait, we view it as something that unfolds during interactions with others, artefacts, and the broader cultural environment. This view is grounded in socio-cultural theory, which emphasizes how actions are mediated by cultural tools such as language, routines, and artefacts (Vygotsky, 1978; Hilppö et al., 2017; Kim & Roth, 2016).

Children's agency becomes particularly visible in open-ended and informal play contexts, where they engage with topics that matter to them. Research in early childhood education highlights how children take initiative, act creatively, and contribute to shared practices when invited to investigate relevant topics and express themselves through multiple communicative forms such as gestures, language, and material use (Siry et al., 2016; Siry & Gorges, 2019). Cho (2023) similarly demonstrated how guided storytelling and play support children in integrating personal meaning-making into structured content.

In studies of technology-mediated play, agency also manifests itself when children resist instructional tools. Odgaard (2023) shows how children reconfigure educational robots to

serve imaginative and social purposes, for instance by turning them into companions or household props. In such cases, children do not reject the task, but rather appropriate it in ways that reflect their own priorities and perspectives. These moments, while seemingly off-task, represent forms of democratic empowerment where children redefine what is possible through the activity.

Additionally, we draw on the concept of transformative agency developed by Kajamaa and Kumpulainen (2019), Rainio (2010), and Rajala et al. (2013). Through this perspective, agency is understood as a continuous, non-linear process that emerges from tensions and practical actions in a socio-material setting. Rather than being limited to acts of resistance or change on a collective scale, transformative agency can also be seen in small, everyday moments. This is where children break away from routines, propose alternatives, or reshape the rules at play. We follow a relational and temporal approach based on Emirbayer and Mische (1998). Their model conceptualizes agency as simultaneously shaped by past experiences, present possibilities, and imagined futures. In this view, agencies include both receptivity and action. Children must first become attuned to cultural tools and expectations; a process Kim and Roth (2016) describe as *passibility*. This concept highlights the importance of being open to the affected before acting. In our study, some children often begin by observing from the sidelines, exploring or lingering before engaging more actively. Rather than seeing these moments as signs of disengagement, we understand them as part of a broader movement of agency in the activity.

Taken together, these perspectives allow us to analyze agency as a fluid movement between openness and action, observation, and reconfiguration. The perspectives enable us to examine when and how children participate in computational play. In addition, they enable us to examine how they reposition themselves, stretch the boundaries of the activity, and express ownership of the learning situation.

Legitimate peripheral engagement and learning trajectories in play

To understand how children engage in computational play, this study draws on the concept of legitimate peripheral participation. This concept was introduced by Lave and Wenger (1991) and further developed by Karoff (2011) in her work on play and learning in educational settings. From this perspective, learning is not primarily an individual cognitive process, but rather a social and situated activity that unfolds through participation in shared practices.

Children do not always participate fully in play activities. Rather, their engagement may initially be peripheral, characterized by observation, tentative attempts, or temporary withdrawal. Importantly, such participation is not passive; it is a legitimate way of gaining access to norms, rhythms, and expectations of a given practice. Karoff (2011) highlights that watching others can be a meaningful form of participation, through which children develop a sense of practice. This involves both an embodied and contextual understanding of what is taking place and how to take part on their own terms.

To conceptualize how children's participation changes over time, this study also draws on the notion of trajectories of participation, as introduced by Lave and Wenger (1991) and further elaborated on in the learning sciences (e.g., Furberg & Ludvigsen, 2008; Rasmussen, 2012). In this context, a trajectory does not imply a linear or predefined path. Rather, it refers to the evolving and situated nature of engagement across time, space, and practice. Participation trajectories account for how learning emerges in the moment while also stretching across

broader timescales, linking past experiences, present interactions, and future possibilities (Ludvigsen et al., 2011). Participation, then, can be understood as movement along what Wenger (1998) later described as the trajectories of participation. These are pathways through which individuals shift from peripheral involvement toward more central roles within a community of practice. However, as Karoff (2011) points out, such movements are rarely linear or predetermined, especially in playful learning contexts. In play, participation often unfolds in circular, fragmented, or exploratory forms, and the practice content is not fixed in advance. Instead, it emerges dynamically through children's actions and ongoing meaning negotiation.

This understanding is central to the present study. Children were observed moving in and out of computational play activities, sometimes withdrawing, rejoining, or regaining. By observing others, they learned how to modify task structures and explore various modes of engagement. When seen through the lens of legitimate peripheral participation and trajectories of participation, such actions appear not as signs of disengagement but as expressions of agency, children finding their way into and shaping a shared practice on their own terms.

Methods

This study investigates an intervention designed to support the exploration of computational play in early childhood education. The intervention was carried out in collaboration with educators, institutional leaders, a local IT consultant and the design company *Guldastronaut*, who specialize in play-based pedagogical worlds. Together, these actors co-created the »Stella and Raffi« play-world – a set of unplugged activities, storylines, and materials inspired by the children's local environment. The play-world included a storybook, 65 activity cards, and construction guides designed to introduce CT concepts (such as sequencing, decomposition, pattern recognition) through storytelling and building activities with DUPLO bricks and arts and craft material.

The study focuses on unplugged activities facilitated by two educators from one of the kindergartens. The educators and the children had no experience with computational play prior to the intervention. In total, approximately two hours of video recordings were collected across four activity sessions, supported by detailed ethnographic field notes. A typical session followed the read–learn–play framework: the educator first read aloud from the Stella and Raffi storybook (read), then introduced a scaffolded activity such as building a lighthouse with DUPLO bricks (learn) and finally allowed children to reconfigure the story and materials through open-ended improvisation (play). This methodological approach made it possible to pay attention to subtle, moment-to-moment interactions between children, educators, and materials (Ash, 2007; Heath et al. 2010; Derry et al., 2010). Figure 1 below shows an image of some of the material that has been produced in the project.



Figure 1. *Stella og Raffi – The Bottle Post* (left) and *Stella and Raffi activities* (right) designed by Guldastronaut

The analysis combined video-based microanalysis with ethnographic interpretation to identify key patterns in how children engage in computational play. Particular attention was paid to how participation unfolded through children's movements, expressions, and interactions with physical materials. In addition, how educators responded and adjusted their facilitation. All video data were segmented into activity units and coded with attention to shifts in participation. Selected episodes were then transcribed for close micro-analysis. One follow-up interview was conducted with one of the participating educators, selected by the general manager, to further explore their reflections on supporting children's learning and participation in the activities. The limited number of interviews reflects the small scale of the study, but the combination of video data, field notes, and educator reflection allowed for triangulation (Creswell & Creswell, 2018).

Participants and study limitations

The empirical material for this study was generated through video observations of a single educator team working with computational play activities in a Danish kindergarten. The team consisted of two educators and a group of seven children aged 4 to 6 years. The children included two girls and five boys. Focusing on one setting enabled a detailed microanalytic approach, allowing for the identification of nuanced moments where participation, material engagement, and agency unfolded in dynamic ways. The choice of DUPLO and familiar story-based activities reflects a child-cultural perspective, where everyday materials from children's own play worlds become central mediators of meaning and agency.

Table 1. Overview of participants

Educators	Children	Age range	Girls	Boys
2	7	4–6 years	2	5

The study prioritizes participation and agency rather than learning outcomes or curriculum impact. All participants were informed about the purpose and scope of the study. Written consent was obtained from the children's parents or legal guardians prior to data collection. The study followed ethical guidelines for research with young children, emphasizing

voluntary participation, confidentiality, and the right to withdraw at any time (Creswell & Creswell, 2018). The children's perspectives and comfort were prioritized throughout, and the educators were actively involved in co-designing the activities to ensure alignment with existing pedagogical practices and relational dynamics. As a small-scale qualitative study, this project is limited in scope and generalizability. It focuses on a single kindergarten setting and a short-term intervention, which allows for detailed microanalysis but does not capture long-term developments or broader institutional dynamics.

Research ethics and children's participation

This study draws on a sociocultural perspective, where learning and agency are seen as situated, relational, and co-constructed through participation in shared practices (Vygotsky, 1978; Lave & Wenger, 1991). This also informs the ethical approach to working with young children. Rather than viewing children as passive subjects of research, the study recognizes them as active meaning-makers, whose experiences, actions, and interpretations are central to the research process (Pramling Samuelsson & Asplund Carlsson, 2008; Hilppö et al., 2017).

Accordingly, ethical considerations were not limited to consent procedures but embedded in the everyday interactions during fieldwork. Care was taken to ensure that children's participation was voluntary and respectful of their evolving forms of expression and comfort. For example, children could choose whether to be filmed, step in or out of activities, and express themselves through gestures, materials, or silence (Kirk, 2006). The role of the researcher was shaped by an ethic of responsiveness, where attentiveness to children's signals, moods, and actions guided the documentation process (Kim & Roth, 2016). In this way, the research aimed to align with the ethical imperative of listening to children not only in what they say but also in how they act, resist, or reframe participation. This aligns with an understanding of ethical research as situated and dialogical, requiring sensitivity to power dynamics, embodied presence, and the everyday complexity of children's experiences in educational contexts (Kirk, 2006).

Analytical strategy

The analysis is based on understanding children's participation as situated and dynamic. Participation is not viewed as fixed or linear but as something that develops over time through children's shifting engagement with educators, materials, and peers (Karoff, 2011). Children may observe, actively engage, step back, or re-enter activities. To investigate how these movements take shape and how agency is expressed in computational play, we drew on Ash's (2014) macro-meso-micro framework for video-based interaction analysis. The analysis was therefore organised across three analytical levels: macro, meso, and micro (Ash, 2014). Each level provided a different perspective on how participation and agency unfolded during the sessions. Table 2 presents an overview.

Table 2. Analytical levels

Level	Focus	Method	Outcome
Macro	Gaining overview	Reviewing and coding video data with attention to changes in participation	Coding scheme and overview of engagement patterns
Meso	Creating direction	Selecting episodes based on shifts in participation and material use	Selected episodes for detailed analysis
Micro	Creating meaning	Close analysis of interactions between children, educators and materials	Descriptions of participation trajectories and expressions of agency

At the macro level, the aim was to gain an overview of how participation developed throughout the sessions (Ash, 2014). The video recordings were segmented into activity-based units, and a coding scheme was applied to trace visible shifts in how children engaged. These included moments of joining, leaving, or returning to the activity and changes in how the educators and materials structured the play. Notes were taken to capture emerging patterns in children's movements and interactions.

At the meso level, episodes were selected based on specific criteria, including shifts in children's engagement, transformation of materials, role changes, and educator interventions that redirected the play (Ash, 2014). These episodes allowed for a closer examination of how children re-entered activity after withdrawal, and how the environment facilitated or constrained participation.

At this level, specific episodes were selected for closer examination based on the following criteria:

- *Changes in the level or form of children's engagement*
- *Children's use of materials to explore or reconfigure the activity*
- *Shifts in the structure or direction of the play situation*
- *Instances of re-entry after temporary withdrawal*
- *Changes in the educators' facilitation (e.g., from instruction to open-ended support)*

At the micro level, selected episodes were analyzed in detail using video-based microanalysis (Ash, 2014). The analysis focused on how children negotiated their position within the activity through subtle forms of interaction, including gestures, positioning, and spoken contributions. Particular attention was paid to how children moved between peripheral and central forms of participation. In addition, these movements were influenced by the unfolding dynamics of the situation. Drawing on ethnographic field insights, the analysis traced how children explored the activity space, tried out roles, observed others, tested ideas, and made sense of the practice over time. These close readings provided a nuanced understanding of participation unfolding through small, situated actions shaped by timing, context, and social relations.

Participation was understood as a continuous process shaped by children's timing, actions, and relationships. Instead of viewing participation as a matter of being either involved or not involved, the analysis explored how children constructed meaning through shifting levels of engagement and changing positions within the activity. In particular, the concept of transformative agency helped to identify moments where children not only adapted to the activity but reconfigured its direction or logic, often in improvisational ways.

Results

From chaos to participation

From the data, we can see how children's agency unfolds through shifting participation. The session began in a state of high energy and disorder as a large box of DUPLO bricks was poured onto the floor. The sound was overwhelming, prompting several children to cover their ears. Some children jumped up and began building spontaneously, while others stood still, walked around, or simply stared at the overwhelming pile of bricks (Observation, 9:01 a.m.). Rather than representing disinterest, these varied responses mark different entry points into the activity. These behaviors reflect how children negotiate their involvement according to participation trajectories (Lave & Wenger, 1991; Karoff, 2011). Some observe at the periphery, while others enter immediately. One girl, for instance, quietly scanned the floor for white bricks, while another counted out eight bricks aloud, and a third focused on finding the largest brick she could (Observation, 9:03 a.m.). These acts of sorting, counting, and searching show how children gradually reframe chaos into a purposeful activity and working computationally. »You need to get used to the fact that it may seem chaotic; you have to read, build, draw and cut, and get children involved« (Educator, interview), the educator later reflected, highlighting how the multi-modal nature of the activity can feel messy to adults even though children engage productively.

The next activity was scaffolded by the educator, who introduced a printed instruction sheet showing a lighthouse model (Figure 2) and asked, »Can you count how many bricks we need?« Although the instructions specified red and white, a child responded, »If we don't have those colors, we can just use green and yellow« , and the educator affirmed this suggestion (Observation, 9:04 a.m.).



Figure 2. Pictures of the lighthouse in different forms

This moment demonstrates transformative agency (Kajamaa & Kumpulainen, 2019), as the child's suggestion modifies the intended task and creates space for individual contribution. The educator's openness legitimizes the child's reinterpretation and allows for a new trajectory within the shared practice.

The shift from chaos to focus, from unstructured interaction to collaborative building, illustrates how agency can emerge through tension-laden transitions. Initially, the scene

resembled playful disorder: bricks everywhere, no clear structure, and varying degrees of engagement. Yet, through the combined influence of material affordances, peer actions, and educator support, children began to create order, explore possibilities, and take ownership of the activity. Their actions were not merely reactions to educators' directions, but small-scale interventions that redefined the task.

Divergent trajectories

A further episode from the same building session highlights how children enact agency through divergent forms of participation. While most children are gathered around Educator 1, who is reading the story aloud to scaffold the »read« phase of the activity, one boy is seated apart at the edge of the room, focused intently on building a bridge from DUPLO bricks (see Figure 3). His creation is not related to the current narrative theme, yet Educator 2 notices and acknowledges his effort with a positive comment (Observation, 9:03 a.m.).



Figure 3. Boy in the left corner building a bridge

This moment illustrates a form of peripheral participation that is meaningful. The boy is not disengaged; rather, he constructs his own narrative thread. His individual focus reflects a self-directed entry point into the broader activity. By recognizing his initiative without redirecting him, the Educator 2 affirms that participation can take multiple forms, not all of which need to align directly with the planned task.

While most children are working to build a lighthouse according to the instruction sheet, one boy who also helps to build the bridge finds a white brick, using it as a reason to join the two girls already working on the lighthouse (Observation, 9:05 a.m.). This small gesture signals a change in trajectory: from parallel activity to collaboration, from peripheral action to central involvement.

Together, these observations underscore how agency unfolds in diverse, non-linear ways, shaped by materials, social interactions, and recognition from educators. »They came a bit in and out of the activity; it's okay if they step away for a while and then come back« (Educator, interview), her emphasizing that peripheral participation was expected and that the facilitators actively encouraged re-engagement. While the storytelling activity provides structure, the

children create meaning and direction through imaginative divergence, resource sharing, and spatial positioning.

Transforming the narrative

One compelling example of how children enact agency within computational play emerged during a storytelling activity in kindergarten centered on the character »Momse« and the theme of baking a cake. The activity began in a structured format, with the educator reading aloud from a storybook. However, the flow of the activity changed when a boy interjected, »Should we bake a cake?« The educator replied, »Not today,« prompting the child to immediately propose an alternative: »A LEGO cake?«—a suggestion the educator warmly accepted: »That's a good idea – you can do that« (Observation, 9:36 a.m.).

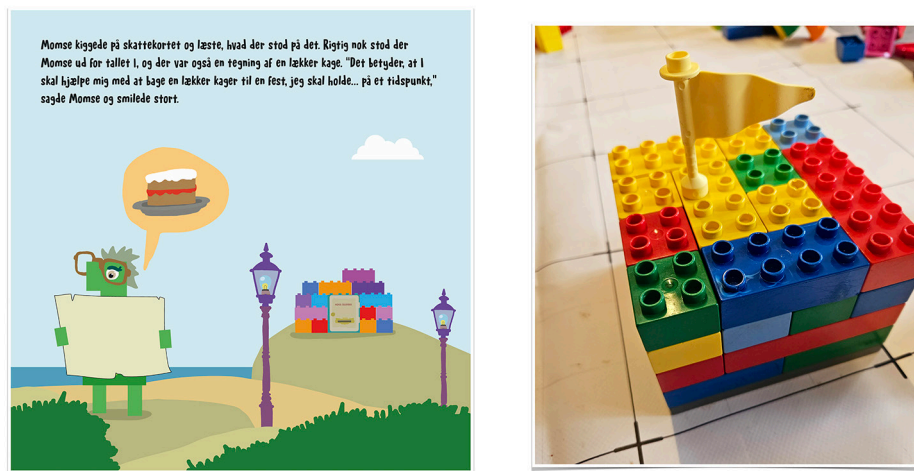


Figure 4. »Momse's Cake« – materializing the story

This image in Figure 4 shows a LEGO cake constructed by one of the children in response to the story about Momse. The child's creation reflects a transformation of the narrative into a tangible, playful object that combines storytelling, imagination, and construction. Rather than following a predefined model, the child reinterprets the cake using available bricks, mixing colors and shapes freely. The result is a hybrid form that merges the educator's read-aloud moment with the child's own meaning-making process. This material response exemplifies how children's agency emerges through creative reconfiguration, turning structured inputs into playful expressions anchored in their own interpretations. It also demonstrates how the read, learn and play principles are applied, but not followed strictly or in a linear fashion, but used as a framework for exploration in the activity.

This micro-moment exemplifies transformative agency as defined by Kajamaa and Kumpulainen (2019): a tension-laden but generative shift in practice, initiated by the child's proposal to reimagine the activity. Rather than complying with the planned narrative structure, the child envisions an alternative direction and mobilizes the surrounding material (DUPLO bricks) to act upon that vision. The child's initiative shifts the interaction from a passive listening mode to a creative building mode. His agency unfolds in the tension between order (the story structure) and emergent possibility (the play idea), demonstrating

how computational play can serve as a space for exploratory reconfiguration rather than task completion. Crucially, the educator's affirmative response enables the transition and signals a form of legitimate peripheral participation (Lave & Wenger, 1991), which becomes central to authorship as the child reframes the activity. His proposal is deeply embedded in the shared context, story, material, and interaction. It illustrates how children's agency is enacted through social negotiation and imaginative contributions. The moment reflects the kind of transformation process described by Kajamaa and Kumpulainen (2019) as dynamic, ongoing, and shaped by tensions within the social and practical context. The child does not adapt to the activity; he repositions it. His action illustrates how even brief interventions can carry transformative potential, especially when the educator's facilitation remains open and responsive. »You don't have to stick rigidly to the tasks; you don't have to build all the figures« (Educator, interview) the educator emphasizing that children's creative suggestions were welcomed over strict adherence to a plan.

The idea of a LEGO cake does not arise in the child alone, but in the encounter between the atmosphere of the story, the physical presence of the bricks, and the educator's response. Rather than viewing agency as an individual capacity, this episode reflects on a relational and emerging process. It illustrates how children participate on their own terms by reshaping structured learning moments into personally meaningful experiences.

Collaborative imagination

As part of the »read« phase, the educator engaged the children in a story involving food and taste. Rather than simply listening, the children were invited into the narrative space through open-ended questions: »What does green taste like?« »Should it be on your hot dog?« (Video observation, Educator 1). These speculative prompts blurred the line between storytelling and play, encouraging children to mix imagination with interpretation. This invitation led to a sequence where children constructed pretend hot dogs out of DUPLO bricks. Figure 5 shows the activity describing how the children can build their hot dogs.

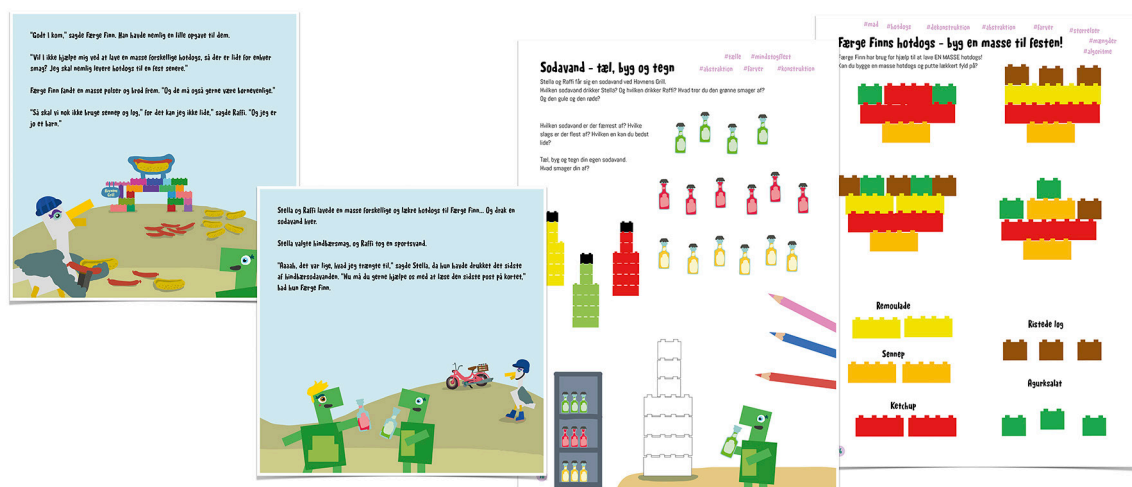


Figure 5. Building a hot dog

One child added strawberries to a hot dog, and another introduced soda made from green and blue bricks. These constructions were not framed as incorrect or off-task but welcomed by the educators, who responded with humor and curiosity. DUPLO bricks were no longer just construction toys; they became semantic materials, actively shaping play as children infused them with various meanings. Rather than following a set goal or instruction, the children collectively reconfigured the activity's purpose. This aligns with transformative agency in its emergent and improvisational form (Kajamaa & Kumpulainen, 2019), as children push the frame of what counts as »correct« or »relevant« and insert their own meanings into the shared practice. »I thought it was great that they just build their own thing when there aren't enough pieces; they develop their own ideas ... it ended up being a cake with trees on top« (Educator, interview), the educator recalled, illustrating how children reinterpreted the narrative prompts.

As a result, participation was fluid and multimodal. Some children began quietly building, others offered commentary (»mine has strawberry on it!« as the child proudly noted), and others watched before joining. This aligns with the notion of legitimate peripheral participation (Lave & Wenger, 1991), where engagement is not linear but marked by shifting positions, explorative gestures, and affective attunement to the group. Through this dynamic, we see how agency is not only about task completion but about shaping the task itself. The hot dog activity is re-authored by the children, transforming it from a story-based prompt into an open-ended, collaborative design session. Their contributions are not random. They are anchored in a narrative framework and infused with playful tension. In this sense, agency emerges as an interplay of imagination, negotiation, and material expression. At the same time, the design of the activities and the affordances of the materials actively invite children to take initiative and shape the direction of the play.

Discussion

This study examined how children's agency unfolded within computational play activities in a Danish kindergarten context. Across all the episodes analyzed, agency emerged not as a fixed attribute or as compliance with predefined tasks. Instead, it emerged as a fluid, negotiated process shaped by children's actions, interpretations, and shifting positions. Through moments of disruption, redirection, and creative invention, children shaped the meaning, structure, and direction of computational play activities. In line with the concept of transformative agency (Kajamaa & Kumpulainen, 2019), several children proposed alternatives to given instructions or reframed narrative prompts into creative, imaginative constructions. These shifts, such as turning a picture of a cake into a LEGO-based design activity or reinterpreting a hot dog into a strawberry-filled construction, highlight how children do not merely engage with content; they reconfigure it on their own terms. Their contributions often unfold in tension-filled spaces between order and chaos, instruction and improvisation, illustrating how agency is activated through movement, affect, and interaction.

The concept of participation trajectories (Lave & Wenger, 1991; Karoff, 2011) further helps to highlight the non-linear nature of children's engagement. Children moved between peripheral observation, central participation, and temporary withdrawal. This was not a sign of disinterest, but part of their ongoing negotiation of meaning in the activity. Educators' open facilitation style was central to this process as well as the design of the activities. Rather than

correcting or redirecting divergences, they allowed space for exploration, enabling multiple forms of legitimate participation.

Importantly, although the activities were not framed as formal computational thinking (CT) instruction, the children's engagements reflected core CT concepts such as pattern recognition, sequencing, decomposition, abstraction and flexible problem-solving (Bers, 2018; Angeli & Valanides, 2020). For instance, in the lighthouse activity, children counted, sorted, and combined bricks to match a model, showing early decomposition skills. In more imaginative contexts, such as the reconfiguration of narrative prompts into LEGO cakes or sodas, they demonstrate algorithmic creativity and conceptual abstraction.

This aligns with Odgaard's (2023) observation that children often appropriate educational technologies, such as robots, for their own playful purposes, subverting expected algorithmic outcomes. Although our study used unplugged materials, we observed the same dynamic: children reconfigured tasks to fit social and imaginative goals. In this sense, computational play is not merely about following instructions but about co-defining what counts as CT through children's situated practices. Framed within a child-culture perspective, familiar materials and narratives (e.g., DUPLO, storyworlds) become cultural resources children mobilize to assert agency, renegotiate rules, and shape activity trajectories on their own terms.

These findings support the view that CT can be meaningfully explored through playful, developmentally appropriate activities grounded in children's interests and lived experiences. Thus, this study contributes to a growing body of research arguing for an expanded understanding of computational thinking in early childhood, one that integrates agency, imagination, and playful participation rather than relying solely on coding or digital instruction (Bers, 2022; Critten et al., 2022). It also highlights the importance of educators willing to embrace computational play's unpredictable and emergent nature. By recognizing children as capable co-creators of activity, and by responding to their initiatives with openness, educators can help create the conditions for meaningful exploration of CT in ways that honor children's developmental and expressive capacities, while also supporting inclusive learning environments where all children can engage, contribute, and explore at their own pace.

Conclusion

This study explored how young children enacted agency within computational play. By examining a Danish kindergarten, we showed how children's participation unfolded through dynamic movements between observation, experimentation, and creative reconfiguration. Rather than following predetermined instructions, the children actively shaped the direction and meaning of the activities. They did so by improvising, by resisting structure, and by introducing their own ideas into the shared play context.

Our findings emphasized that computational thinking could be approached as a lived, playful, and socially negotiated practice, not limited to formal coding tasks. Children's actions illustrated key CT concepts such as sequencing, decomposition, and abstraction, while also showing how these concepts emerged in multimodal and affective ways.

By combining transformative agency and participation trajectories, we proposed a broadened understanding of computational play. This understanding highlighted children's capacity to imagine, improvise, and influence learning activities. It required educators to engage not only as instructors but as co-explorers who recognized and supported children's situated forms of participation.

In this way, computational play became more than a means to teach skills. It became a space where children's perspectives, meanings, and contributions were taken seriously as part of the learning process. Future research might investigate how computational play can be supported and scaled across diverse early childhood settings. In particular, there is a need to explore how educators can be trained to recognize, value, and respond to children's imaginative and agentic contributions within CT activities. Longitudinal studies could also help illuminate how participation trajectories and transformative agency develop over time and across changing institutional contexts.

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