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Mundane Practices on the Edges of Intentional Design in a Maker Project

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Abstract: Maker-centered learning engages students in the creation of tangible artifacts. We focus on the edges of this intentional design process, where mundane materially entangled practices that are not driven merely by human intention happen. We build on theoretical perspectives that consider practices as assemblages and matter as active, relational, and dynamic. Together with teachers, we conducted an invention project in Finland. Students aged 14 to 15 designed and built smart products in small teams. To understand the continuity of details, we analyzed video recordings of three teams' design sessions on three levels: the macro, intermediate, and micro. The analysis framed the learning process as a balancing act. In addition to performing the learning task, students simultaneously created functional artifacts and adapted their creative flow to the institutional rhythm of the school classroom. Materiality created messiness and unpredictability but also provided tangible boundaries that allowed for action amidst this uncertainty.

Introduction

A key aspect of maker-centered learning is idea materialization, the transformation of abstract ideas into tangible forms. Working with tangible artifacts has been found to support learning that is multimodal and transactive across settings (Peppler et al., 2021). With our background in craft, design, and technology education, we perceive the idea materialization process as an entanglement of designer and matter, where the human maker learns from matter and thinks with it (Heimer, 2016). However, much activity takes place at the edges of this intentional design process, such as spontaneous play, matter that is entangled with sociopolitical questions (Vossoughi et al., 2016) or knowing beyond traditional academic skills (Kuby et al., 2015). We focus on these edges and mundane materially entangled practices that are not driven merely by human intention, but also affected by, for example, materials and technologies (Bodén et al., 2019).

Sensitizing ourselves to details and more-than-human relations does not offer universal facts. Instead, such a perspective helps us to recognize issues that call for response (Haraway, 2016). A focus on the wider connections between details can make actors hiding in mundanity, such as commercial corporations, visible (Decuypere, 2019). Appreciating moments of uncertainty and nonlinearity can help us to notice opportunities to support learning that places learners as part of the world, not outside observers, which is crucial in future education (Common Worlds Research Collective, 2020). To better understand the multiple fluid practices (Mol, 2002) that take place in a maker-centered learning project, we ask: How is the idea materialization process enacted in classroom practices?

Theoretical approaches

We understand idea materialization as an iterative and nonlinear process that includes constructing, evaluating, and revising various material models, such as sketches, mock-ups, prototypes, and final artifacts (Kangas et al., 2013). Our longstanding research in craft, design, and technology education helps us to avoid blindly adopting branded definitions of making, which, as Vossoughi et al. (2016) argue, can limit maker-centered learning to technological innovation aimed at contributing to economic growth. Our understanding of making emphasizes aspects such as embodied knowledge (Heimer, 2016) and wide-reaching material connections (Latour, 2005).

Widening the scope of our inquiry to the edges of intentional design allows us to explore the unverbalized practices that emerge during idea materialization. This approach helps us to understand the multiple realities that take shape in the classroom (Bodén et al., 2019). Placing special emphasis on acknowledging material agency as part of sociomaterial entanglements, we build on theoretical perspectives that consider practices as assemblages and matter as active, relational, and dynamic (Bodén et al., 2019; Haraway, 2016; Mol, 2002).

We begin by acknowledging that matter matters; it can transform situations (Latour, 2005). However, this material agency is not a static attribute but is instead enacted in relations (Mol, 2002). Therefore, instead of single actors, our focus is on the heterogeneous entanglements of human- and nonhuman actors and sociomaterial encounters in which humans and nonhumans transform each other (Latour, 2005). These transformations and effects of encounters are not predetermined; thus, we do not seek to establish fixed or stable roles of matter. Instead, we consider the practice of materialization to be fluid assemblage, which is constantly changing (Mol, 2002). We purposefully do not predetermine who or what participates in enacting the materialization. The more-than-human relations that constitute materialization cannot be clearly formulated in a neat network, as reality is not always logical (Mol, 2002). Thus, we do not seek universal epistemic claims but theoretically grounded situated knowledge (Haraway, 2016; Decuypere, 2019).

Methodology

For several years now, we, together with teachers, have conducted co-invention projects in elementary and secondary schools as part of regular curricular activities. This study focuses on a project that took place in spring 2019 in a Finnish upper secondary school. Students aged 14 to 15 designed and built smart products in small teams. The project lasted for 8 weeks and involved 17 sessions, lasting 75 minutes each. The orientation phase (three sessions) included a coding workshop, a lecture from a professional designer, and a visit to a design museum. During the initiative ideation phase (three sessions), students oriented themselves toward problems in their everyday lives and the artifacts involved in those problems. Teachers formed teams of three to four students, and these teams chose one initial idea to be developed and materialized, first as a mock-up and then as a functioning prototype (10 sessions). Finally, teachers organized an in-class invention fair, where students presented their inventions and gave and received constructive feedback (one session).

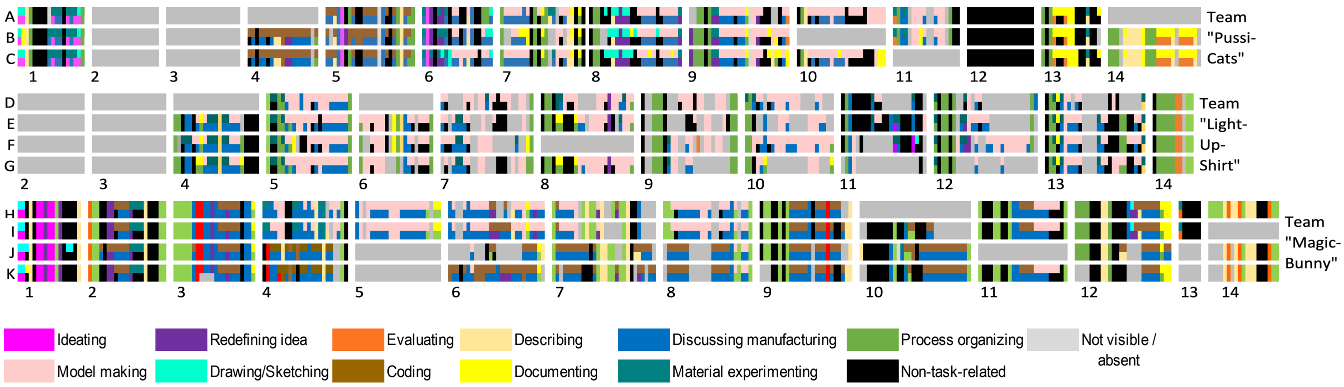
The first two authors were present at the school throughout the process. After orientation, we video recorded the 14 design sessions of three student teams. The inventions of these teams were named (by the students themselves) the Magic Bunny (a smart piggy bank that counts the money inserted), the Light-Up-Shirt (a garment with decorative LED lights that adjust to the environment), and the Pussi Cat (a smartphone bag that heats up if the temperature drops). To understand the context of the making process and the continuity of details, we analyzed video recordings (approximately 44 hours) on three levels: the macro, the intermediate, and the micro.

On the *macro level*, we engaged with the data by weaving a "Making-Process-Rug" (Riikonen et al., 2020). We went through the video recordings systematically and coded the main verbal and embodied design activities in 3-minute segments. This allowed us to create a visualization of the intentional design process (Figure 1). The Making-Process-Rug acted as a basis for the next level of analysis as well as provided a background for reflecting the relations among multiple aspects of idea materialization.

On *the intermediate level,* we unraveled dichotomies between classification and wonder (MacLure, 2013) by allowing the productively slow (Ulmer, 2017) coding process to guide our attention toward the edges of the intentional design process. We sought events that did not quite fit in the coding scheme but appeared still to be related to the idea materialization. On *the micro level*, we focused on details. We paid attention not only to the words, talk, and gestures of the students but also to the material aspects of the process by considering sounds, space, rhythm, and movement.

Finally, we considered these three levels along with complementary data. We reflected on how the micro-level details were present in student interviews, portfolios, and our field notes. This wider perspective enabled us to analyze how the materialization was enacted in nonlinear trajectories across the entire process. This thinking process was guided by theoretical concepts of material agency (Bodén et al., 2019; Latour, 2005) and fluid assemblage (Mol, 2002).

Figure 1
Making-Process-Rugs. Each color represents a different verbal or embodied action. Numbers 1 to 14 refer to the design sessions, and letters A to K refer to the students.



Findings

In this paper, we focus on three aspects of the idea materialization process. For all student teams, the process was simultaneously a learning performance, the emergence of a functional artifact, and an adaptation to an institutional rhythm.

The material constraints of the process affected and refined the nature of the *learning performance*. All details of abstract flowy ideas had to be concretized while coding. For example, blinking lights and the sounds of the microcontroller gave feedback on coding actions (Figure 2, Magic Bunny), demanding precise and detailed actions. The functionalities of commercial coding software (Microsoft MakeCode for Adafruit Circuit Playground) constrained the ideas that could be materialized and how they were materialized. When combined with the constraints of time, knowledge, and material resources, the materiality of coding required students and teachers to simplify the idea to make it an appropriate learning performance that was challenging enough but not unachievably difficult.

Technology actively shaped the process (Latour, 2005), and students had to think together with matter (Heimer, 2016). This allowed knowledge to emerge without verbalization (Kuby et al., 2015). However, the effect of technology was unpredictable and occurred regardless of preplanned process structures (Bodén et al., 2019); it was not merely a consequence of intentional design experiments. The central role of software and educational technology obscured the dichotomy between local mundane practices and global commercial actors (Decuypere, 2019). When the idea was adjusted to match the material resources, the multiplicity of the process was momentarily coordinated into a whole (Mol, 2002), resulting in a balancing act between ambitions and skills.

In addition to a learning performance, the process was also the emergence of a *functional artifact*. For example, the Light-Up-Shirt team mostly focused on making shirts that would complement their existing wardrobes or duplicate existing favorites (Figure 2, Light-Up-Shirt). These tangible objects were connected to the students' everyday lives beyond school. The open-ended design task allowed students to create artifacts that were meaningful for them, not merely to complete prefixed tasks. Sewing the smart LED lights onto a detachable piece of fabric allowed the students to fulfill the requirement to use digital technology with minimal effort. This balancing act between learning performance and personal interests illustrated how different aspects of the process were able to co-exist and interact (Mol, 2002).

The idea to be materialized was not abstract nor merely human to begin with but was instead informed by qualities of existing artifacts. The presence of artifacts embedded the process within wider society and cultural phenomena, such as fashion and consumer culture. Although these issues were not deliberately or verbally addressed, they were present in the artifacts (Latour, 2005).

The process was an adaptation to an *institutional rhythm*. The materialization process had to be adjusted in accordance with predefined school schedules, resources, and practices. Neither teachers nor students could have known beforehand how much time making the artifact would take; materials provided surprises. Even though the Pussi Cat team often engaged in non-task-related chat during design sessions, their making process flowed faster than anticipated. To make use of the allocated time, the team added decorative elements to their invention (Figure 2, Pussi Cat). The fragmented nature of the process, determined by the school schedule, demanded practices to facilitate transitions, such as routines for organizing the required materials in specific places after use and tracking the process with portfolios. In addition, the tempo of movement within the classrooms thickened toward the ends of the sessions, when students worked to finish their ongoing tasks.

Learning with matter (Heimer, 2016) extended from making design choices to balancing creative flow with institutional resources through material actions. Formal and informal aspects were allowed to co-exist by distributing them to different modalities (Mol, 2002), for example when progressing the learning performance by embodied means while verbally discussing informal issues.

Figure 2
Ongoing idea materialization: Magic Bunny (a), Light-Up-Shirt (b), Pussi Cats (c)

(a) (b) (c)

Conclusions and implications

The coexistence of multiple aspects of idea materialization made the learning process a balancing act. The aim was not only to materialize design aspirations but also to cope with local resources, such as school schedules, the societal connections of objects, and the functionalities of the technologies of making. This materiality turned students' general inventions into situated artefacts, embedding abstract issues within tangible details at hand.

Furthermore, the open-ended design task and unscripted making sessions gave students space to act on their own terms. Much of this action took place on the edges of the intentional design. The material details of the designed artefacts were able to serve multiple, even contradictory purposes simultaneously. Non–task-related activities were neither opposed nor alternatives to task-related activities. Instead, the mundane activities provided opportunities for learning to cope with local requirements.

Methodologically, becoming sensitive to such multiple realities in the classroom requires that researchers acknowledge the agency of materiality and eagerly follow even surprising trains of thought prompted by data. In our case, going systematically through the video data gave us space to wonder at the ordinary and zoom in on what did not quite fit into predetermined categories. Instead of being deterministic explanations, theories acted as sensitizing devices, guiding the gaze toward fluid assemblages.

We have suggested an approach that examines classroom practices happening at the obscure boundaries of on-task and off-task activity. The aim is to evolve the understanding of the purpose of learning from mastering the world to cultivating responsible, situated action. In practice, such a perspective could be implemented by exploring how craft practices, which provide enabling constraints, could be utilized in various educational settings beyond maker-centered learning.

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