Facilitating STEAM Learning among Children with Paper Circuit Activities

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Abstract
The study explores paper from an ethnographic perspective. It focuses on paper as a material that facilitates the production and retention of STEAM (Science, Technology, Engineering Arts, and Maths) knowledge in children. In an after-school activity with elementary and secondary school children in Germany, a paper project was conducted that revealed how the crafting of paper circuits promotes both creative craft skills, as well as technical ability. Identifying key structural elements of the projects, we argue that the process of using, creating and questioning through, with and for the technology inherent to the paper project activities permitted the children to gain both access to STEAM knowledge and thereby build creative agency and technical self-efficacy.

Author Keywords
Children; Crafting; Circuits; Learning; Making; STEAM.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI); K.3.2 Computers and education, literacy.

Introduction
Paper has long inhabited a key role in the production, storing and management of knowledge [2]. Paper is also a material that has begun to emerge as a possible

lens to understand creative skill building within craft principles and informal learning contexts [4,5]. We explore paper from an ethnographic perspective. Our study focuses on paper as a material that facilitates the production and retention of STEAM (Science, Technology, Engineering Arts, and Maths) knowledge in children, a type of mindset that can be nurtured in this population [1].

In an after-school activity with elementary and secondary school children in culturally diverse neighborhoods in Germany, we explored the STEAM philosophy of education, which promotes the idea that skill building in children needs to support both creative engagement and technical self-efficacy as indicators of success. With this approach, our activity expands previous works of Rode et al. (2015) arguing for computational making as an educational framework for teaching computing [3].

Method

Our activity with a mixed gender sample of boys and girls, aged 8-13, conducted a project that revealed how the crafting of paper circuits actually promotes both creative craft skills, as well as technical ability. Over the course of the activity, our participants created pop-up cards from paper, paper flowers, 3D paper models, different personal ideas (e.g. a paper airplane, MineCraft characters), and then illuminated those constructions with built-in paper circuits, with varying degrees of input from the researchers and other participants.

Findings and their Discussion

The first steps of the activity involved the children to gather ideas which were discussed with the other participants and the researchers. For better visualization of the idea, different representations of their projects were constructed. These *multiple representations* contained chalk drafts on a blackboard or on sketch-pads with a pencil, rough drafts of ideas, as well as virtual 3D models. Children had to understand how to transfer the 2D draft into a real world representation of their idea and especially how to incorporate the circuit without short-cutting it by crossing the copper wires.

Our activity showed how the paper projects promoted the development of a strong sense of *aesthetics* among the participants. This was the case, e.g. when participants were seen to rebuild their projects over and over again, until they were confident with the appearance. In crafting, participants firmly linked the aesthetics and the functionality of their projects, aiming for the artefacts to simultaneously 'look good' and 'function properly'.

Furthermore, our activity showed that paper was a good material to foster *creativity* among the participants, as it allowed for easy prototyping. Even those participants, who initially turned to ready-made patterns, insisting they 'cannot do handicraft work', ultimately could not resist to start experimenting with shapes, colors and sizes in the designs of their artifacts.

This process of simultaneously building creative agency and technical self-efficacy did not go without moments of *breakdown* and failure, e.g. when a plan for a construction design did not work out as imagined, or the material did not react as envisioned. Even though several of these breakdown situations initially resulted

in frustration and even the destruction of the entire artifact by its creator, they ultimately lead to a deeper understanding of making and crafting processes.

The construction process of the project artifacts consisted of several steps and involved a variety of physical skills: after sketching their drafts, participants had to reconsider how to materialize their idea using paper (e.g. creating an airplane with attached, functioning wings). The children faced different challenges using utensils and materials due a lack of practice with this equipment (e.g. too much glue was applied, or the thick end of the scissors was used for fine paper cuts). Our activity showed how *understanding materials* was a needed skill to determine the course of action – as was seen, e.g. when a child sketched the layout of a cube onto the blackboard to visualize his idea, but instead of transferring this cube shape onto paper for further processing, he tried to cut out the cube free-handedly with his scissors while looking at the draft on the blackboard. Other children were seen to experiment with mechanical connections, trying to create levers or latches from paper in order to make their designs flexible and customizable (e.g. a paper lantern that could change its faces, or a paper monster that could 'express' different emotions).

Conclusion

Identifying key structural elements of the projects, we argue that this kind of paper crafting activity can function as a transformative investigation providing opportunities for collaboration and learning among children. The process of using, creating and questioning through, with and for the technology inherent to the paper project activities permitted the children to gain both access to STEAM knowledge and thereby build creative agency and technical self-efficacy.

Access to the Poster:

https://www.dropbox.com/sh/muvqkhh2fjlzncy/AAC0qDpYwveaPEO65LDR29mDa?dl=0

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