Assessment of Creativity During Family Engineering Workshops in Informal Learning Environments

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Abstract: The learning sciences faces challenges assessing creativity. As such, we examine how a creativity assessment tool (the SVS novelty metric) differentiated product features and 31 families' engineering practices, which was confirmed via video-based interaction analysis. Findings from analyses suggest that SVS novelty metric may be a useful tool in differentiating learners' products within the same product category because they reflect the overall pattern of engineering practices when families engage in makerspaces in informal spaces.

Introduction and background

As research on making moves beyond highlighting creative practices in making (Vossoughi & Bevan, n.d.), there is a need for expanded frameworks to explore the interplay between the practices and the products of creativity. Towards this goal, we investigated if, and to what extent, a creativity assessment tool differentiated the product features and reflected learners' engineering practices during making. We chose SVS metrics (Shah, Vargas-Hernandez, & Smith, 2003) among the two outcome-based creativity assessment tools (i.e., CAT, SVS) for its assessment of relative creativity in a local context rather than using subjectivity of the experts.

We operationalized engineering practice as interaction related to considering problems in context, inner workings in teams (e.g., persisting and learning from failure), use of data to make decisions, use of tools and strategies for problem solving (e.g., envisioning multiple solutions, investigating properties of materials, constructing models), and finding solutions through creativity and innovation (Cunningham & Kelly, 2017).

Methodology

As part of a larger design-based research (DBR) project (Barab & Squire, 2014) called *STEM Pillars* for families with elementary-aged children, this study focused on hour-long engineering workshops from the second DBR iteration that incorporated littleBits at four libraries and one museum. Two engineers led the workshops. Each engineering workshop provided time to explore the littleBits, simple challenge (design lantern, flashlight, tickler, waver without instruction), and complex challenge (design an interactive toy for a sick neighbor). We collected video and audio data (~21 hours of video, 18 hours of audio), fieldnotes, and photographs of families' products. Out of 75 participants, 31 parent-child pairs (unit of analysis) were analyzed.

We created content logs and invention logs for each parent-child pair. We identified and transcribed the complex challenge episodes; they became the focus of our analysis. We assessed 31 products using the SVS novelty metric. Following the feature tree approach, two raters used equation 1 ($f_i = \frac{T - C_i}{T}$, T is the total number of products in the data set and C_i is the total number of products that incorporated the feature i), and equation 2 ($D_j = \frac{\sum f_k}{\sum f_i}$) to calculate the novelty of each product (D_j is the novelty of jth product, f_k is the sum of f_i in a product). The Cohen's Kappa (inter-rater reliability) was 0.867. The full detail of using the SVS novelty metric is reported in our prior study (Kim & Zimmerman, 2019).

Lastly, we conducted within-product category and between-product category analysis based on fieldnotes, content logs, and transcriptions to examine in what ways the novelty scores differentiated the product features and the families' engineering practices. We looked at families' products between different product categories to select deviant cases that had high novelty scores despite plausibly less engagement of families' engineering practices. Emergent trends were discussed and reviewed during a thematic analysis.

Findings

Our preliminary analysis suggests the usefulness of the SVS novelty metric in differentiating product features and reflecting the overall pattern of the families' engineering practices when the products they created are within the same category. In 11 product categories in our dataset, there was more visible evidence of the families' engagement in the engineering practices when their products had higher novelty scores. From the 31 families, we present two cases that created flashlights to illustrate the finding (Figure 1). In Nathalie and Bruce (9 years)'s family, the lack of visible evidence of engagement in engineering practices aligned with the low novelty score. Nathalie and Bruce did not engage in explicit discussion on what to design. Nathalie only checked his progress:

"*Is it working*?" In Riley and Sawyer (8 years)'s family who created a jack-o-lantern flashlight with a higher novelty score, the jack-o-lantern flashlight resulted from layers of previous episodes of their engagement in engineering practices such as envisioning multiple solutions and finding solutions through creativity. Riley's suggestion on making a hole on the paper that covers the flashlight ("*If you made one side, like dark, and then just poked a little hole through here*") enabled modifications on their design ("*Oh, good idea! Okay, I kinda want to do something like this*").

Parent-child pair	Nathalie-Bruce	Ryan-Liam	Alexis-Brooklyn	Ryan-Eli	Riley-Sawyer	Silvia-Derek
Novelty score (range 0-1)	0	0.06	0.12	0.21	0.27	0.29
Final product	Flashlight that changes color	Flashlight with a cat drawing	Flashlight with two colors	Fall-proof flashlight	Color-changing jack-o-lantern flashlight	Color-changing flashlight with handle

Figure 1. The products and novelty scores within the flashlight product category from the SVS novelty metric.

Our preliminary analysis also highlighted that the novelty scores did not differentiate the novelty of product features and reflect families' engineering practices in between-product category groups, as illustrated in two family cases (Figure 2). Analysis of Yunsu and Charlotte (8 years)'s family showed that they engaged in multiple engineering practices. They discussed various disabilities to define the problem and decided to design a wheelchair. Due to lack of materials to create wheels, they engaged in another episode of envisioning solutions and designed sunglasses with a light and a fan. They investigated available materials, used a motor and plastic blades to create a fan. As such, they collaboratively engaged in multiple engineering practices to design their product. In contrast, there was no visible evidence—through verbal or gestural indicators—that Kaylee and Blake (6 years) engaged in more instances of engineering practices than Charlotte and Yunsu despite a higher novelty score. They designed an everything machine by combining their simple design artifacts (i.e., flashlight, waver, tickler) to a branch Bit. The everything machine had a higher novelty score of 0.43 as a result of serving multiple purposes. This case highlights how novelty scores may not align with the overall pattern of families' engineering practices, and points out the limitation in differentiating the product features that may be regarded as more novel regardless of the infrequency of an idea compared to others.

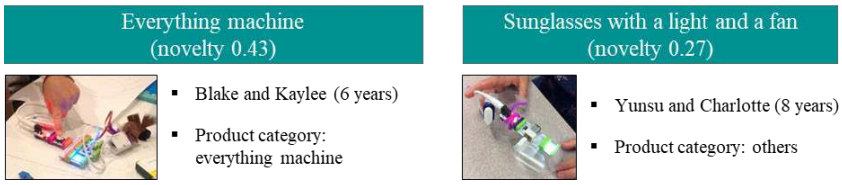

Figure 2. Blake and Kaylee's everything machine (left) and Yunsu and Charlotte's sunglasses (right).

Conclusion

Our findings expand the learning sciences understanding of the affordances and the limitations of the SVS novelty metric in educational settings that capitalize on making. Previous understandings of the SVS metrics, given its outcome-based focus, was that it would not be suitable for reflecting on the activity aspect of learning (i.e., engineering practices). Our findings based on 31 parent-child pairs suggest that the product and the activity aspects of creativity aligned when the products were within the same product category. This points towards the usefulness of the SVS novelty metric in assessing learners' inventions and projects made in makerspaces. In our poster, we further discuss the implications of this finding to support educators and practitioners concerned with creativity assessment of youth and families' making and tinkering products in various educational settings.

References

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