Maker-Material conversations: A Case Study from a Makerspace in India

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Introduction

Making is recognized as a means to engage learners in creative engineering design as it provides opportunities to solve real-world problems, following different ways to arrive at multiple solutions [1]. Collaborative making practices bring out skills in tackling uncommon problems and constructively engaging in design [2], and foster engagement with technology, collaborative knowledge sharing, and creative production [3]. In collaborative making, creative thinking takes a distributed form through interaction between people, dialog between people and objects, or interactions over time [4], [5]. In the course of hands-on making activities, maker-material interaction results in *being*, *doing*, and *becoming* material conversations [6].

Being material conversations considers the materials as familiar, whereas *doing* material conversations involves examining known material affordances and *becoming* material conversation defined by transformed purpose, reconfigurations, and modifications of materials [6].

Drawing from all these prior literature, we look at how novice makers and materials get into being, doing, and becoming conversations, during collaborative creative making.

Analysis

Data for this study was collected as part of a maker workshop series organized at a leading engineering institute in India. The participants of this study were second-year mechanical engineering undergraduate students, who were familiar with Lego Mindstorms EV3 kit. Based on the order of response to invitation for the study, eight students were grouped into four teams, with each team consisting of two members. During this digital fabrication workshop, participants were given a design challenge: *Conceptualize an assembly line/production line that is semi-automated with static and dynamic robots. Model and build the setup with resources available in the makerspace.* A facilitator (F) was present during the making sessions to support the teams with conceptual and procedural guidance. This study focused on one of the student teams, Team B, consisting of two male students S1 and S2. Each team was provided with two Lego Mindstorms EV3 kits, a 3D printer, 3D printer pen, knives, scissors, screwdrivers, cardboards marking pens, pencils, chopsticks, play-doh modeling compounds, cable ties, tapes, glue, styrofoam sheets, a box consisting of used ropes, wires, and papers.

We used the SVS metrics [7], to assess the outcomes of the making activity, and focused on measuring the novelty component of the metrics as the participants in the study produced one type of idea (building robots for package movement), and the activity did not constrain to strict design specifications. Novelty is measured as the infrequency of an idea compared to all the ideas present. Idea features were identified and a genealogical tree was developed with the following levels: goal, working principle, functional unit, transfer, motion, and material details. The ideas were then independently rated by the author and a fellow researcher, and achieved high inter-rater reliability, Cohen's kappa = 0.893. Feature novelty of each idea is calculated as the ratio of difference between total number of ideas and total number of ideas in which the particular feature is addressed, to the total number of ideas. The novelty score for each idea is calculated as the ratio of the sum of the feature novelties to the number of features addressed for each idea.

We follow the case study methodology [8] to follow Team B's making process. We used the content logs to conduct interaction analysis [9] focusing on talk and the use of artifacts and technologies, and identified 'significant moments' for analysis by looking for discussions on design decisions, participants talking with and through materials, and dialogic exchanges between participants [6] .

Findings

According to SVS metrics [7], Team B scored the highest novelty score of 0.63 among the teams, who completed the task. We present a few instances from Team B's making activities to show the ways in which maker-material conversations occurred.

A. *Package holder*

The makers followed a concept for the assembly line, where a dynamic robot carries a package from a location and the static robot picks the package to place it on other conveyor belts. S2 created a structure to hold the package, out of the lego kit parts and wheels, as shown in Fig. 1. The maker identified the frictional property of the rubber tyre that can hold the package, and connected it to the structure. Here the maker, lego parts, and wheels are involved in *doing* material conversations as the property of the tyre is explored for holding purpose, wherein tyres and wheels are usually used for rolling functionality. Also, the Lego connectors and frames are considered for building structures in conventional ways, denoting *being* material conversations.

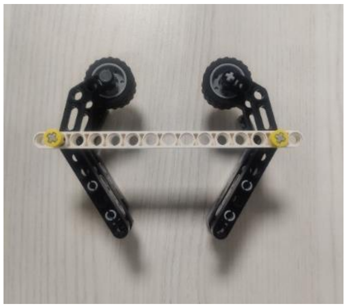

Fig.1 Gripper made with lego kit parts and wheels

B. *Slipping parts*

As the making progressed, S1 and S2 came together to build the static robot structure. While making the structure, makers used lego motors, leg kit parts, cardboard pieces, play-doh and tapes. The following excerpt shows how different maker-material configurations impact the externalization of novel ideas in terms of prototypes.

S2: [testing the robot base with a lego motor] mm..it is rotating.. but coming off

S1: [checks the robot base] these not holding together.. these gears [pointing to gears]

S2: Slipping.. and coming off

S1: Wait.. [gets the tape] will wrap these.. then lower gear won't slip.

S2: From top and cross?

S2: Yes.. [cuts the tape and wraps]

Fig.2 Tape-Gear combination as robot base

Here, the makers worked on building a base so that the robot can rotate about the vertical axis. The base is made using lego kit parts, and tested. In testing, the makers found that the gears are slipping apart, hindering the rotary motion. S1 found the tapes at the work table and wrapped a piece around the gears, as shown in Fig. 2. The tape–gear combination was then tested with lego motors, and the assembly proved to be a compatible base for the static robot. With acts of combining the tape and gear sets to arrive at a transformed functionality of the material assembly, the maker along with the material resources engage in *becoming* material conversations, to overcome the slipping problem of gears and other parts.

Discussion and Conclusion

We have presented a few instances from an empirical case study of making, showing how novice makers are getting involved in *being, doing,* and *becoming* material dialogues while solving a design challenge with the resources available. As the makers attempted to tackle the problems, a wide range of materials from Lego Mindstorms EV3 kit components to mundane materials were used. The makers acted upon these materials, to which materials responded and "talk backs" continued till the goal achievement or failures occurred [10]. In the making sessions, we have seen makers conversing with fellow makers and materials, resulting in learning of material characteristics and creative design possibilities [11]. These sociomaterial conversations can involve shared agency, which reiterates the material aspect of distributed creativity, and materials cannot be considered as dormant [12]. Further analyses from various making contexts would give more refined understanding of makers' creative making practices.

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