Exploring Team Innovation in Makerspaces
6th International Symposium on Academic Makerspaces

ISAM 2022 Poster No.: 144

Lisa M. Casper[1], Elizabeth S. Veinott[2]
[1]Lisa M. Casper; Dept. of Cognitive Learning Sciences, Michigan Technological University; e-mail: lcasper@mtu.edu
[2]Elizabeth S. Veinott; Dept. of Cognitive Learning Sciences, Michigan Technological University; e-mail: eveinott@mtu.edu

Introduction

One of the critical 21st-century skills students need is to be able to think differently [7]. Makerspaces and design thinking have become part of university innovation education strategies across the world to help students develop these skills [6];[3]. But how do we support innovation in makerspaces? At Michigan Tech, we use design thinking in conjunction with the makerspace. Using a cognitive engineering approach, we conducted interviews with five experienced makerspace developers and managers [2]. In this presentation, I will review research on makerspaces and innovation theories with a backdrop of the design thinking process. Using cognitive task analysis, we interviewed expert makers from Europe and the United States and conducted a thematic analysis of the data. Themes from these interviews suggest focus areas for future experiments that will support innovation in makerspace.

Background: Innovation and makerspace

Examining innovation research relevant to makerspace, Kajamaa & Kumpulainen [4] studied collaborative learning and reported on four types of multimodal knowledge: orienting, interpreting, concretizing, and expanding knowledge. They found that students with different domain expertise compensate by collectively solving challenges.

Some qualitative studies have systematically documented what good makerspace-making looks like related to innovation. Andrews and Roberts [1] used observations, questionnaires, and structured interviews and found that the reconfigurable characteristics of makerspace led to collaboration and make it easier to participate in peer-to-peer learning. Sheridan et al., [5] conducted a longitudinal field study comparing three makerspace environments and found that the most common makerspace strategies included tinkering, playing with tools, and puzzling out solutions. They concluded that the multidisciplinarity of the team and a shared story led to innovative solutions.

Makerspace research has focused on cognitive and collaborative strategies [4]; [1] but has not centered on how makerspace supports innovation, which is our focus. Through understanding psychological processes that occur with innovation we can develop experiments to further explore these factors with the goal of developing strategies that support innovation in makerspace. To better understand the relationship, we conducted two studies.

Study 1

Study 1 was a part of a Fall 2021 program evaluation survey at the end of a design thinking makerspace exercise. Both studies were approved by the University Human Subjects review board.

Method

Thirty-five students in the makerspace, worked in teams of 3-4 people on a design thinking exercise to prototype an inclusive game. The Alley Makerspace is an open room with modular tables, it includes tools, whiteboards, and prototyping carts with low-fidelity prototyping supplies, such as duct tape, foam boards, popsicle sticks, post-its, and sharpies.

Procedure

Students were led through a two-hour design thinking process that included a framing activity in which they brainstormed to create a game that they would like to make more inclusive for an individual with a disability. They were guided to develop a rough prototype using supplies provided and prototyping carts. Key activities included: empathy interviews, collaborative brainstorming using "yes and", brainstorming with constraints, and team prototyping. Following the activity, students provided an evaluation of the event which included three questions (Table 1). Open-ended responses were content coded by two independent raters who achieved high interrater reliability for the coding scheme (Cohen's Kappa = .82 which controls for chance agreement.)

Results

Students were given surveys with three questions (Table 1). Overall, students thought that their team's ideas were highly innovative (7.6 on a 9 point scale). Teams generated on average 7 inclusive game ideas during the exercise (range from 1-20 ideas). When asked about the process, 71% reported they felt that they generated more ideas than other brainstorming techniques, 28.5% said about the same, and 8.5% reported generating fewer ideas. When asked what was innovative about the process, students' most frequent answer was brainstorming with 22.8%, followed by the constraint narrow prompt (17.1%) and the "Yes and" (both part of the ideate process) (Table 2).

Table 1 Study 1 Self-Report Survey of Innovation Results

Innovation Questions	Mean (SD)
Question 1: How innovative was your team's design? 1-9 (Not at all to Very Innovative)	7.64 (1.78)
Question 2: About how many different game design ideas did your team generate?	7.06 (5.6), range of ideas were from 1-20
Question 3: Compared to other brainstorming techniques that you have used in the past; did you generate more ideas of fewer interesting ideas?	6.33 (1.77)

Table 2 Study 1 Self-Report Survey of Innovation Results

Question: What part of the design thinking process do you think most supported your team's innovativeness?	Percentage of Students (Raw Frequency)
Brainstorming/ideate	22.3% (8)
Constraint Narrow	17.1% (6)
"Yes and"	14.3% (5)
Collaboration	11.4% (4)
Empathy	11.47% (4)
Voting	8.57% (3)
Prototyping	5.7% (2)
No editing	5.7% (2)

Overall, students thought their ideas were innovative and more innovative than other brainstorming techniques they have used.

Study 2

Study 2 captures stories of innovation and actual makerspace projects.

Method

Using a Cognitive systems engineering tool, Cognitive Task Analysis (CTA) [2] was used to conduct semi-structured interviews to capture makerspace stories. The goal was to identify the cognitive processes involved in team innovation in makerspace environments.

Procedure

Each interview was conducted via Zoom by two interviewers and took about 60 minutes. One interviewer asked CTA questions while the other took notes. Each interview included three sweeps, going deeper into the response each time.

Results

Participants generated 11 makerspace stories in which something innovative happened. The timelines for these projects ranged from one to six weeks. Of interest was a citizen science project, in which stakeholders were willing to collaborate and make personal sacrifices to develop a Covid-19 solution. Another was a bike design project for challenging terrain. These interviews were coded and systematically analyzed. Because these stories focused on innovation, themes that emerged from the interviews included: Experimentation, Co-Creation, and Perspective Shift. Experimentation involved playing with ideas, solutions, and methods to come up with innovative solutions. The theme of Co-creation is part of collaboration and involved the team building off each other's ideas. Finally, Perspective Shift involved changing one's perspective on a problem.

Summary

Results from both studies are consistent with the literature, but provide some additional evidence and new insights. Design thinking produces ideas that students rated were innovative, and that helped them generate more innovative ideas than other methods they had used. Students thought the brainstorming in design thinking including constraint and the "yes and" activity supported the innovation process. From real-world design thinking projects identified in Study 2, several themes emerged. For example, the innovation literature highlights the importance of collaboration between team members [1], [4], [5]. When individuals collaborate they naturally consider different perspectives in order to understand the stakeholder and users. Through this increased empathy, teams create meaningful innovative solutions. Narrowing focus through constraints, shifts a team's thinking towards a common story, so more solutions are generated. Future research on makerspace innovation and team innovation will be testing some of these ideas in larger class environment, and experimentally testing the innovation strategies.

References

[1] Andrews, D., & Roberts D. (2017). Academic makerspaces: Contexts for Research on Interdisciplinary Collaborative Communication. In *Proceedings of the 35th ACM International*

Conference on the Design of Communication. https://doi.org/10.1145/3121113.3121230\

[2] Crandall, B., Klein, G., & Hoffman, R. (2006). *Working minds: A practitioner's guide to cognitive task analysis.* Cambridge, MA: MIT Press

[3] Hasso Plattner Institute of Design at Stanford. (n.d.). "Epicenter: Creating a nation of entrepreneurial engineers." University Innovation Fellows. Retrieved July 24, 2022, from https://universityinnovationfellows.org/about-us/program/

[4] A. Kajamaa., & K Kumpulainen (2020). "Students' multimodal knowledge practices in a makerspace learning environment." *International Journal of Computer-Supported Collaborative Learning*, *15*(4), 411–444. https://doi.org/10.1007/s11412-020-09337-z

[5] K. Sheridan, E. R. Halverson, B. Litts, L. Brahms, L., Jacobs-Priebe, L., & T. Owens (2014). "Learning in the making: A comparative case study of three makerspaces." *Harvard Educational Review*, *84*(4), 505–531. https://doi.org/10.17763/haer.84.4.brr34733723j648u

[6] V. Wilczynski, A. Wigner, M., Lande,, & S. Jordan (2017). "The Value of Higher Academic Makerspaces for Accreditation and Beyond." *Planning for Higher Education Journal*, 46 (1),1-1.

[7] S. Zahidi,, V. Ratchev, G. Hingel, G., & S. Brown (2020). (rep.). *The Future of Jobs Report 2020* (pp. 35-36). Geneva, Switzerland: World Economic Forum