Making "Math Making" Virtual

Brock Education

A journal of educational research and practice

2020 Vol. 29 (2) 30-36

https://journals.library.brocku.ca/brocked

Candace Figg,* Anjali Khirwadkar, Shannon Welbourn

Brock University

Abstract

Due to the COVID-19 pandemic, university professors are challenged to re-envision mathematics learning environments for virtual delivery. Those of us teaching in elementary teacher preparation programs are exploring different learning environments that not only promote meaningful learning but also foster positive attitudes about mathematics teaching. One learning environment that has been shown to be effective for introducing preservice teachers to the creative side of mathematics—the mathematics makerspace—promotes computational thinking and pedagogical understandings about teaching mathematics, but the collaborative, hands-on nature of such a learning environment is difficult to simulate in virtual delivery. This article describes the research-based design decisions for the re-envisioned virtual mathematics makerspace.

Keywords: makerspaces, making, online learning, teacher preparation, virtual learning environments

* candace.figg@brocku.ca

The 2020 COVID-19 pandemic brought with it the need for all teachers, even university professors, to adjust delivery of instruction. In the mathematics methods courses offered by Brock University's Teacher Education program, making mathematics relevant to elementary preservice teachers so that they truly understand the omnipresence of mathematics in daily living had been the greatest challenge until the pandemic required all instruction to move online. Now, faced with designing instruction that ensures modeling of best practices for teaching mathematics, the new challenge is re-envisioning how collaborative mathematics activities can be adjusted to ensure meaningful learning takes place virtually. Specifically, this article reimagines organizing mathematics makerspaces and our design decisions in making "math making" virtual.

Makerspaces in Brock's Mathematics Methods Course for Elementary Preservice Teachers

Often faced with comments from preservice teachers that "Math is about following some set rules and procedures" or "Solving mathematical problems overwhelms me so I don't connect myself with the subject," Brock's methods instructors strive to change these negative perceptions about mathematics, which are rooted in the personal encounters of preservice teachers' K–12 experiences (Akerson, 2017; Bekdemir, 2010), so that the misunderstanding that mathematics is only a subject of rules and procedures is not passed along to future students (Wood, 1988).

A makerspace is "a creative and uniquely adaptable learning environment with tools and materials, which can be physical and/or virtual, where students have an opportunity to explore, design, play, tinker, collaborate, inquire, experiment, solve problems and invent" (Meyer et al., 2018, p. 3). With the potential to expose preservice teachers to the creative side of mathematics by providing avenues for play, experimentation, and interdisciplinary connections, makerspaces encourage student acts of knowledge generation rather than mere consumption (Iwata et al., 2020). As well, the *making* mindset that is developed from participating in makerspaces fosters creativity and innovation, risk-taking, and problem-solving by providing a safe environment to explore ideas and inviting the learner to think in different ways with a "can-do attitude" (Dougherty, 2013, p. 9).

Indeed, Brock's mathematics makerspaces were found to effectively promote holistic mindsets about teaching mathematics in three areas: preservice teachers engaged in computational thinking throughout participation in the makerspace activities and described their thinking in computational terms; they developed confidence with, and knowledge about, how to teach effectively with technology tools to promote mathematics understandings; and they connected curriculum learning goals with makerspace activities, thereby identifying the value of makerspaces as alternative learning environments for the teaching of mathematics (Figg & Khirwadkar, 2019; Khirwadkar & Figg, 2019).

Making Makerspaces Virtual

With mathematics methods courses taking place virtually for Fall 2020, the question becomes how to adjust the makerspace experience effectively so that it remains a valuable and meaningful learning experience. Fortunately, research exploring virtual makerspaces is emerging. Lock et al. (2020) describe the act of virtual making as

> the process of synchronous and/or asynchronous making in an online environment. It can involve a virtual (i.e., Internet-driven or virtual-reality) environment to create, build and invent (Loertscher, 2015) that supports makers in direction, asking questions, sharing work, and giving and receiving feedback (Oliver, Moore, & Evans, 2017) while at a distance. (p. 3)

Access to collaborative others who provide support, guidance, advice, and feedback during the making process is essential to virtual making. This is accomplished in virtual makerspaces in two ways. Asynchronously, makers work at a distance on their project, then meet virtually with others specifically for the purpose of sharing creative work and eliciting feedback. Or, makers can meet synchronously at a specified time for the purpose of doing the making together—which simulates experiences in the face-to-face makerspaces (Lock et al., 2020).

Brock's 2020 Virtual Makerspace

In the original, physical mathematics makerspace stations, five stations were set up, which were stocked with all necessary supplies, tools, resources, and guides required to work with the materials/resources at each station. Preservice teachers spent 20 minutes at three of the stations, spending the first 10–15 minutes exploring and creating with the materials, and the remaining 5–10 minutes documenting their K–8 curriculum math connections, engaging in pedagogical discussions with others at the table, and recording reflections about what they were learning.

We quickly found that there was much more to contemplate in the re-envisioning process of physical station activities, which had been selected for their close alignment with the mathematics curriculum, to virtual environments. More than simply adapting the activities for digital environments, three design considerations required attention.

First, participants would supply their own materials which would substantially influence how and what participants created in some stations. For example, finding *Ozobots* and *Robots* available in home environments was unlikely; therefore, the redesigned virtual stations substituted *Scratch* coding and the *Code Your Family* activity. Participants would also need detailed directions for how to participate in ways to simulate the open exploration act in the physical makerspaces. Guides and an online station website would have to be created (see Figure 2), with lists of possible materials to collect, instructions for participating virtually in makerspaces, and curriculum guides and suggestions for participating in the station.

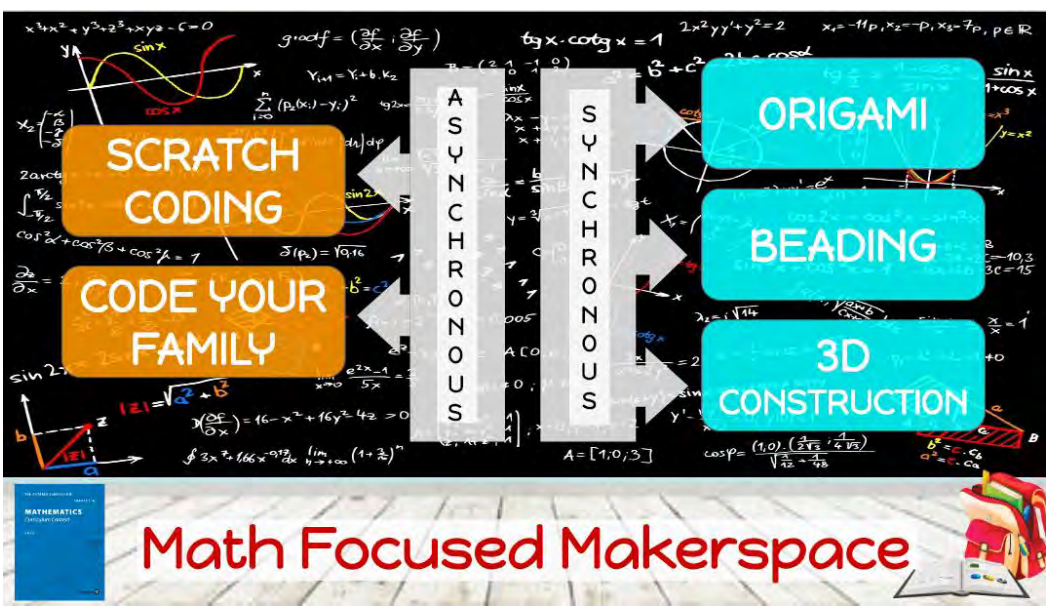
Figure 1

Physical Makerspace Stations

Note. Left: for origami (where participants used papers of various sizes/colours to explore geometrical properties). Right: for beading (where participants create various artifacts applying the concept of growing/shrinking patterns).

Figure 2

The Online Station Guide for Mathematics Makerspaces



Note. Available at: https://tinyurl.com/y4wk45mp

Next, to participate in pedagogical and curriculum discussions around the making (the essential reason for the makerspace experiences), participants would need a virtual meeting space to simulate the face-to-face interactions. *Microsoft Teams* rooms and *Sakai* forums, our videoconferencing tool and learning management system available at Brock, would need to be established.

And finally, we realized that it was not feasible to conduct all the stations synchronously as some of the redesigned virtual station activities would best be accomplished individually and shared later. Therefore, it was necessary to review the five redesigned stations for ease of completion in the synchronous and asynchronous environments; the decision was made to break the virtual makerspace into 2 weeks, with asynchronous makerspace activities taking place in week 1 and the remaining synchronous makerspace activities in week 2. The asynchronous pedagogical learning could be documented through online journaling or reflections in forums, whereas the synchronous discussions with teammates could be documented through video-recording the session. Figure 3 provides details on the resulting three virtual environments that work together to provide a virtual mathematics makerspace experience.

Figure 3

Chart of Three Types of Virtual Spaces to Support the Virtual Mathematics Makerspace

Virtual Space Created	Digital Tools	Descriptions
Online Station Guides	Five makerspace activities that provide guidance (through multimodal forms, including video and text), suggestions for materials or resources for use in the station, and specific directions as required by the station activity (See Figure 2). Created in Google Sites.	**Week 1 Asynchronous stations** (participants complete one of the stations and document learning in a forum reflection) • *Code Your Family* (using code to move family members rather than *Ozobots*), and • *Scratch* (replaces coding the *Dash*, *Cue*, & *Onyx* Robots using the *Blockly* app). **Week 2 Synchronous stations** (participants engage in making during a team videoconference where members provide live feedback and advice) • Beading station: Using items found around the home to create beaded pieces, including items such as various pasta noodles, cheerios/fruit loops or other cereal that can be strung onto string, fishing line or shoelace. • 3D Construction: Using cardboard found around the home rather than 3D Doodler Pens or Woodworking. Items such as empty paper towel or toilet paper rolls, empty egg cartons and empty Kleenex/cereal/food boxes can be collected for use. • Origami: Gathering and cutting paper squares for folding from newspapers, flyers, and old papers/notes found in the home rather than fancy folding origami papers.
Virtual Meeting Space	MS Teams or Lifesize videoconference meeting rooms	To provide access to collaborative space with others for working together, giving and receiving feedback, or sharing of ideas supporting the pedagogical dialogue about makerspace activities
Online Journaling Areas	Sakai Forums	Where individual and team participants share pictures, videos, and reflections about curriculum and pedagogy connections experienced in the stations

Conclusion

The mathematics makerspace is valuable for engaging preservice teachers in experiences that make math learning relevant to everyday life, and much more than just learning procedures. Extending the learning community of preservice teachers through virtual makerspace activities and digital tools is one example of how teaching in the age of COVID-19 will not only support the growth of tech-savvy teachers so needed in a digital society, but also promote the development of teachers with a *can-do* mindset—willing to try new approaches and adjusting to meet the needs of their students in different teaching situations.

References

Akerson, A. (2017). Preservice teachers' perceptions of mathematics through drawings. *Kentucky Journal of Excellence in College Teaching and Learning*, *14*(3), 37–53. https://encompass.eku.edu/kjectl/vol14/iss/3

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. *Educational Studies in Mathematics*, *75*(3), 311–328. https://doi.org/10.1007/s10649-010-9260-7

Dougherty, D. (2013). The maker mindset. In M. Honey & D. E. Kanter (Eds.), *Design, make, play: Growing the next generation of STEM innovators* (pp. 7–11). Routledge.

Figg, C., & Khirwadkar, A. (2019). Preservice teachers using makerspaces to address the challenges of teaching digital learners: A self-directed creative exploration. In J. Theo Bastiaens (Ed.), *Proceedings of EdMedia + Innovate Learning* (pp. 1297–1303). AACE. https://www.learntechlib.org/p/210268/

Iwata, M., Pitkänen, K., Laru, J., & Mäkitalo, K. (2020). Exploring potentials and challenges to develop twenty-first century skills and computational thinking in K-12 maker education. *Frontiers in Education*, *5*, Art. 87. https://doi.org/10.3389/feduc.2020.00087

Khirwadkar, A., & Figg, C. (2019). Makerspaces for developing TPACK: A self-directed creative exploration for learning mathematics. In K. Graziano (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 2463–2468). AACE. https://www.learntechlib.org/primary/p/207996/

Lock, J., Redmond, P., Orwin, L., Powell, A., Becker, S., Hollohan, P., & Johnson, C. (2020). Bridging distance: Practical and pedagogical implications of virtual makerspaces. *Journal of Computer Assisted Learning.* Advance online publication. https://doi.org/10.1111/jcal.12452

Loertscher, D. V. (2015). The virtual makerspace: A new possibility? *Teacher Librarian*, *43*(1), 50-51.

Meyer, A., Hansen, P., & Fourie, I. (2018). Assessing the potential of third space to design a creative virtual academic space based on findings from information behaviour. In *Proceedings of ISIC: The Information Behaviour Conference, Krakow, Poland, 9-11 October: Part 1.* http://www.informationr.net/ir/23-4/pdf/isic1814.pdf

Oliver, K. M., Moore, R. L., & Evans, M. A. (2017). Establishing a virtual makerspace for an online graduate course: A design case. *International Journal of Designs for Learning*, *8*(1), 112-123. https://doi.org/10.14434/ijdl.v8i1.22573

Wood, E. F. (1988). Mathematics anxiety and elementary teachers: What does research tell us? *For Learning of Mathematics*, *8*(1), 8–13.