Implementing Digital Graphing Activities in College Algebra: Two Instructors' Views of Benefits and Challenges

Kristin A. Whitmore
CU Denver

Robert Knurek
CU Denver

Heather Lynn Johnson
CU Denver

Livvia Bechtold
CU Denver

Gary A. Olson
CU Denver

Courtney Donovan
CU Denver

We address the transformation of instruction in entry-level college mathematics courses, such as College Algebra. Our research question is: What do instructors view as benefits and challenges when implementing novel digital graphing activities in College Algebra? We report on a case study of two instructors who implemented the activities during both semesters of one academic year, drawing on instructors' individual interviews at the end of each semester. The instructors viewed it as beneficial to implement these activities as part of a community. They also found the activities' focus on reasoning helpful for their students. They found integrating the new activities with existing online learning management systems challenging at times, and they wished their students were more engaged when implementing activities asynchronously. Overall, the challenges were not roadblocks, and the benefits outweighed the challenges. We conclude with discussion and implications for research and practice.

Keywords: undergraduate education, instructional activities, communities of practice, technology

The transformation of instructional practices in introductory college math courses, such as College Algebra, is important for students' persistence in Science, Technology, Engineering, and Mathematics (STEM) degrees (e.g., Freeman et al., 2014; Henderson et al., 2011; Herriott & Dunbar, 2009). Yet, instructional materials in such courses tend to privilege a status quo of finding numeric answers at the expense of promoting reasoning (Mesa et al., 2012). When instructors implement digital activities designed to press against a status quo of answer finding, there can be tension regarding the status of the activities within the course (Olson & Johnson, 2022). For this preliminary report, we investigate the question: What do instructors view as benefits and challenges when implementing novel digital graphing activities in College Algebra? We report on a case study of two instructors, Riya and Carol (pseudonyms), who implemented activities in both semesters of one academic year in conjunction with their participation in a faculty learning community (FLC) (Cox, 2016).

College Algebra is an entry-level undergraduate course at many U.S. institutions. The Committee on Undergraduate Programs in Mathematics (2015) has recommended revisions to College Algebra, including rethinking the class to better support students as logical and quantitative thinkers. However, change has been slow to develop (Tunstall, 2018). Working with innovative digital activities can make room for instructors to question conventions in their curricular materials (Sinclair et al., 2020) and deepen their understanding of mathematical relationships (Moore et al., 2019). By incorporating novel digital graphing activities into College Algebra, we work to affect change in the course. Our case study provides insight into instructors' views on the benefits and challenges of implementing such activities while discussing implications for research and practice.

Background

To explain how instructors may make changes to their instruction via implementing novel digital activities while participating in an FLC, we draw on Wenger's (1998) Community of Practice (CoP) theory. From this perspective, practice is not something people hand down from one group to another; it is ongoing and continually evolving. One way to engage instructors in new practices is to make room for negotiation between the core members of a community and those along the periphery (Wenger, 1998). This way, instructors can "dip their toes" into practice without demanding full participation. For example, instructors may participate by listening to others implement the activities or trying out a new digital activity in their class.

FLCs are common in higher education (Cox, 2016; Kezar et al., 2018). They can form when instructors connect through a common scope of practice and come together to learn and share about a concept or process over time. Communities of Transformation (CoTs) are a special type of FLC. Kezar et al. (2018) define CoTs as "communities that create and foster innovative spaces that envision and embody a new paradigm of practice" (p. 833). CoTs include three aspects: an idea to challenge the status quo, the space to carry out practices, and a group with which to sustain those practices (Kezar et al., 2018). For example, focusing on reasoning rather than finding answers is one way to challenge the status quo in early undergraduate mathematics courses. Interacting with CoTs allows instructors to have space to conduct new practices with colleague collaboration and support.

Methods

Our case study (Yin, 2016) stems from a larger, National Science Foundation-funded project spanning multiple institutions. The project intends to address the overemphasis on finding the correct answer in U.S. undergraduate mathematics education by prioritizing mathematics reasoning. The project aims to transform instruction in College Algebra via instructors' implementation of digital graphing activities, *techtivities,* that emphasize students' reasoning over answer-finding. We report on a case of two College Algebra instructors, Riya and Carol, who participated in the project for one academic year.

Techtivities

The techtivities are digital graphing activities developed in the free, Desmos platform (Desmos, n.d.). Each techtivity starts with animation, such as a "Cannon Man" propelled out of a cannon and then parachuting back to the ground. Students explore the change in two attributes identified in the situation (e.g., height from the ground and total distance traveled) and create a Cartesian graph relating the attributes. They compare their graph to a computer-drawn image and graphs generated by their classmates and reflect on their observations. Then, students sketch another Cartesian graph representing the same relationship between attributes but with the attributes on different axes.

Data Collection

Instructors participated in the project while receiving stipends on a semester-by-semester basis. In their first semester of implementing the techtivities in their College Algebra courses, instructors attended four professional development (PD) sessions via videoconference to accommodate participants from multiple institutions. During these sessions, participants explored features of the techtivities, discussed strategies for implementation, and reflected on the role the techtivities played in their instruction. Co-investigators of the larger project held PDs

roughly once per month. After the first semester, instructors met in small group CoT meetings at their institution to debrief their implementation of the techtivities and share related ideas.

At the end of each semester, instructors participated in 30-minute, individual, semi-structured interviews conducted by video conference. In an instructor's first semester of participation, the interview had four topics: benefits and challenges of teaching College Algebra, benefits and challenges of participating in the project, instructors' views of students' interactions with the techtivities, and the instructors' perceived impact of the techtivities on their teaching. In subsequent semesters, the interview revisited benefits and challenges and student interactions, as well as three additional topics: instructors' views on what constitutes a techtivity and how the techtivities fit within their course, instructors' collaborations with others about the techtivities, and instructors' takeaways from working on the project. Graduate research assistants produced verbatim transcripts for each of the instructor interviews.

Analysis

Instructor interviews were our source of data, analyzed using a modified form of open coding (Corbin & Strauss, 2008). We entered the analysis process with two broad codes, "benefits" and "challenges." By a benefit, we meant something an instructor perceived to be good, helpful, or enjoyable. By a challenge, we meant something an instructor perceived to require thought, skill, or innovation to address.

Whitmore and Knurek led the coding and data analysis. They began by reading the transcripts and watching the videos. Then, they identified excerpts (uninterrupted speech turns from instructors), which they coded as benefits or challenges for the instructor. For each excerpt, they wrote a short field note explaining how they viewed the excerpt to represent a benefit or challenge. To vet the codes, they met in pairs to agree and brought the codes to the larger author team, who weighed the codes against the evidence in the interview and refined the themes emerging from the excerpts and codes.

Results

Our analysis revealed four themes related to benefits and challenges. Instructors' views of the benefits related to the techtivities outweighed the challenges they faced. Benefits included their participation in an instructor community and the value of focus on reasoning. Challenges included integrating the new activities with existing learning management systems and engendering student participation in asynchronous settings.

Benefits

Participating in an Instructor Community. Riya and Carol acknowledged the value of meeting regularly with other instructors while implementing the techtivities. In her second interview, Riya described structuring their small group CoT meetings around discussions about instruction.

> Riya: In terms of me as a faculty, we've been doing something different this year by like visiting each other's classes to check how these go with other instructors. And our schedules were in conflict, so we really didn't get the chance, but we all recorded and met after that. We discussed the recording and giving kinds of answers also about the set of questions, what was our challenges, what we like, what we faced, how things were going.

> And also, you see like the same video from a different instructor perspective, that was really helpful.

Carol found the CoT meetings to be a space where she saw other instructors' practice. She stated, "It was nice to see how other instructors, well, it was just Riya so far, but it's nice to see how they implement this." Their comments pointed to the ongoing nature of developing new practices, as put forward by Wenger (1998). Their implementation of the techtivities was something that continued to develop, not something the research team handed down for them to replicate.

Focusing on Students' Reasoning. Riya and Carol saw benefits for their students as well as themselves. In their view, the focus on reasoning over answer-finding was a positive aspect, which Carol stated that she appreciated in both interviews. In her second interview, Carol shared that this focus was something she wanted to expand in her teaching.

> Carol: I really liked the techtivities, and I would try to continue to have the students focus more on the reasoning and what they think rather than whether they get the right answer, so I'm hoping to maybe do this longer, um, incorporate this into my course, to get them to think versus just trying to find the right answer.

Riya and Carol felt that the techtivities impacted their students' mathematical thinking. In the first interview, Riya described how her students' responses gave her evidence of their learning and engagement.

> *Interviewer*: Do you think that the techtivities impacted your students' math thinking?
> *Riya*: Yeah, sure. I am sure about that one. Most of the answers they were saying that they "didn't think about that." Y'know, or "We didn't know that there is such a relation." or "That's very nice." So, so they were likely engaged with what they have learned from the new skills.

Riya and Carol's comments provided evidence that they were comfortable making room for students to think and hear each other's insights from their work on the techtivities. Notably, their comments suggested that the broader project's focus on reasoning is something that they valued as part of their instruction.

Challenges

Navigating multiple online platforms. Implementing the new activities meant that instructors needed to navigate both the Desmos platform and their learning management system, Canvas. Sometimes the challenges were specific to the platform, and sometimes they involved integration within the system. During her second interview, Riya talked about difficulties she experienced when trying to switch between techtivities on the Desmos platform. She stated: "Sometimes it's very hard to go back to, to go back it takes a while to go back to the techtivity you want, because I was doing two techtivities. So I cannot go from one to another quickly." Both instructors were new to using the Desmos platform, and the research team worked to help them navigate the online venues, both with facilitation guides and online modules.

The research team created a Canvas module for instructors to support different delivery formats. The first semester, Carol had a major challenge integrating the module into her Canvas course. Her upload inadvertently overwrote her course settings. She was quite frustrated and thought about quitting the project. Yet, she appreciated the research team's help troubleshooting the problem and decided to stay on with the project. She reflected on this in her second interview, stating, "Well, the challenge is initially, you know, that I had problems with, with the Canvas site. There was just a technical problem that I had, but it was something that I had last semester." Carol's and Riya's challenges pointed to the complexities of implementing new

digital activities. Not only had they needed to learn the activities, but they also needed to learn to navigate and connect within different online platforms.

Encouraging student participation with asynchronous implementation. Both instructors had autonomy in implementing the techtivities in their courses. When the activities were asynchronous, even in face-to-face courses, instructors found it challenging to encourage student participation. During her second interview, Carol talked about decreased student participation when she assigned the techtivities asynchronously through Canvas.

> Carol: They were always lower for the ones that I assigned through Canvas, where I just tell them, here, this is what you need to do. And I'm just wondering whether there's anything I can do to get them to actually do the ones through Canvas.

Riya's comments also supported her value of synchronously implementing the techtivities when possible. She said in her second interview, "They worked really good this semester, better than last semester. I think the plan is to have the time for all of them to be implemented in the class so we can discuss them in more detail with the students." Riya and Carol's comments spoke to the utility of having the techtivities be something more than an "add-on" to the course, as recommended by Olson and Johnson (2022).

Discussion/Conclusion

We investigated a case of two instructors' views of benefits and challenges when implementing the novel techtivities in their College Algebra classrooms. While the instructors encountered challenges, they were not roadblocks to their implementation. A key benefit was instructors' participation in small group CoT meetings, in which they could discuss and reflect on their practices.

Our case study aims to illuminate how implementing novel digital activities can engender instructional transformation in College Algebra. We offer three emerging contributions. First, instructors' participation in a community, beyond just a researcher-led PD, is crucial for instructors to develop agency in their practice and to allow for new approaches to take hold. When the community is also a CoT (Kezar et al., 2018), instructors have a space to develop new practices to push back against the status quo of answer-finding and to promote students' reasoning in courses such as College Algebra. Second, the status of the new activities makes a difference in students' participation (Olson & Johnson, 2022). Riya and Carol found it difficult to encourage student participation when implementing the activities asynchronously within a synchronous course. Third, implementing new digital activities involves navigating new online platforms, and instructors need to have space to learn that navigation.

Our analysis is ongoing. To further develop the case of Carol and Riya, we will analyze their small group CoT meetings to learn more about how their interactions support their evolving practices. Then, we will triangulate those analyses with evidence from their classroom practices.

Questions for Audience

1. What are your experiences implementing digital activities (or active learning elements) into early undergraduate mathematics courses? What were the benefits and challenges?
2. How do you see FLCs, specifically CoTs, contributing to instructional transformation in undergraduate mathematics?

Acknowledgments

This research was supported by the U.S. National Science Foundation award 2013186. Opinions, findings, and conclusions are those of the authors.

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