INTERACTION TYPES IN ONLINE AND HYBRID MATHEMATICS INSTRUCTION

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Engagement in the mathematics classroom through interactions with the instructor, peers, and content are necessary for an effective learning experience. As such, it is important to understand the types of interactions that teachers utilize to engage students, especially as they have had to shift from a complete face-to-face setting to various remote modalities. Utilizing four interaction types (learner-content, learner-instructor, learner-learner, and learner-interface) this paper analyzes 35 videos of classroom instruction with the purpose of describing the interactions that take place throughout the course of the mathematics lesson. While there was not a significant difference in the type of interaction and the modality of instruction, there was a significant difference in the type of interaction enacted and the modality of instruction.

Keywords: High School Education, Instructional Activities and Practices, Technology, Online and Distance Education

Introduction

While historically providing education through distance and remote learning at the K-12 level was reserved for gifted older students (Campbell & Storo, 1996), the technological advances have allowed for platforms and delivery systems that have made it a feasible means of stretching the walls of the classroom to reach all students (Offir et al., 2003). Teachers have had to contend with the preeminent mindset that distance education works best for independent, self-motivated learners (Chou et al., 2010; Corso et al., 2021) as they try to create learning opportunities that engage all learners with varying ability levels and technological skills.

Teachers tend to try to duplicate their face-to-face instruction when teaching online, which includes trying to replicate different types of classroom interactions (Battalio, 2007; Garrison & Cleveland-Innes, 2005). Interaction is seen as essential to the online educational experience and as such is a primary focus for online learning (Garrison & Cleveland-Innes, 2005). To explore the interactions secondary mathematics teachers have utilized in their online and hybrid teaching, we investigate the research question: *What types of interactions are teachers facilitating in high school mathematics classes across different modalities of online teaching?*

Theoretical Framework

Learner-content interaction is “intellectually interacting with content to bring about changes in the learner’s understanding, perspective, or cognitive structures” (Hillman et al., 1994, p. 30). Moore characterized this form of interaction as a one-way flow of information from the subject matter to the student (Lin et al., 2017) and stated that “without it there cannot be education” (Moore, 1989, p. 2). This interaction includes: conjecturing mathematics, solving problems, confirming one's work, interpreting mathematics, and making predictions.

Moore (1989) claims that learner-instructor interaction is regarded as “highly desirable by many learners-is interaction between the learner and the expert who prepared the subject material, or some other expert acting as instructor” (pp. 1–2). Offir et al. (2003) study refined the five categories of this interaction. These categories are: social, which pertains to classroom climate; procedural, which is dissemination of administrative instructions about the course; expository, which is presenting information by the teacher; explanatory, which is the teacher’s

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use of student input to explain content; and cognitive task engagement, which is the teacher presenting a question/task for the learners to engage in processing information.

Learner-learner interaction is the interaction between learners. Moore (1989) characterized this as the least focused by many within education but essential for younger learners where peer group interactions often aid motivation. We categorized this interaction as the presentation of a solution, responding to another learner, collaborative problem-solving, and small group discussion.

Hillman et al. (1994) recognized that another interaction dimension should be considered in technology-mediated learning environments. This type of interaction is necessary because the students must navigate technology to complete the educational task. While this could be thought of as manipulation of a mathematical object and thus learner-content, the difference lies in that content knowledge is a non-factor during the interface interaction. "Regardless of the proficiency of the learner, inability to interact successfully with the technology will inhibit his or her active involvement in the educational transaction" (Hillman et al., 1994). We operationalized this as responding to a poll or providing an answer via features of a technology medium.

Participants, Data, and Methods

Nineteen experienced high school mathematics teachers from seven districts participated in this study. Teachers had between six and 34 years of experience, with eight being the median years of experience. They had completed a 30-credit hour Master's degree or a 12-hour graduate certificate in mathematics education in Summer 2020. There were 35 videos analyzed for this study. Teachers submitted a video recording of one of their classes from the fall of 2020 (n=19) and an additional video from the spring of 2021 (n=16). Teachers either submitted videos of pre-recorded (Fall-13, Spring-4), synchronous online (Fall-13, Spring-4, hybrid (Fall-13, Spring-4), or face-to-face (Fall-13, Spring-4) instruction. These videos captured the entire class period, including breakout rooms, and were not edited before submission. COVID restrictions in each district dictated the mode of instruction. In the fall of 2020, most teachers recorded a video in advance of their class to post on their learning management system for students to view asynchronously. The videos ranged in length from five to 54 minutes in the fall of 2020 and 15 to 71 minutes in the spring of 2021.

Three levels of coding were applied to the analysis of each video. First, the type of interaction was identified (learner-content, learner-instructor, learner-learner, learner-interface) and coded. Then the second level of interaction was identified and coded. Finally, it was noted if technology was used during the activity.

The researchers, the authors of this paper, met to view a video together, clarify the unit of analysis, and define each of the codes. The unit of analysis was considered a level 2 interaction type. When there was a change in the activity type, that was treated as a new unit to code. For example, a teacher interacting with students to solve a problem would be coded (learner-instructor, solve a problem). If the teacher then provided students with directions about submitting their solution, that would be considered a new unit and coded learner-instructor, procedural (administrative). There were 1,962 total turns for this data, 366 for fall 2020 and 1,596 for spring 2021.

One video was coded together, and then six videos were assigned to pairs of researchers to determine inter-rater reliability. Agreement on units of analysis was determined (87.1%) and agreement on codes on the units that were in common was calculated (86.7%). Once inter-rater reliability was established, one researcher coded the remainder of the videos.

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Data were analyzed using frequencies and Chi-square Test of Independence to determine if there were any significant associations between two categorical variables. Chi-square tests were run to determine if there were significant differences in the type of instruction and level 1 interaction types, semester of video and interaction types, and level 1 interaction and the specific level 2 interaction.

Results

First, an analysis of the number of unique interactions by the type of instruction shows that there were many more interactions in face-to-face instruction (n=928) over the two semesters than in the other types hybrid (n=525), synchronous (n=426), and pre-recorded (83).

During the 2020-2021 school year, mathematics teachers overwhelmingly utilized learner-instructor interactions (74.31%), predominately cognitive task engagement or expository. Of the learner-instructor interactions, 36.87% were cognitive task engagement, 26.32% were expository, and 13.64% were explanatory. Overall, 25.28% of the interactions were learners engaging with mathematics content. Most learner-content interactions involved students solving a problem (52.02% of learner-content interactions) or making a conjecture (44.15%). In addition,

there is evidence that teachers provided a few opportunities for their students to confirm their answers (n=18), predict (n=1), and interpret their solutions (n=0). There were very few learner-learner (n=6) and learner-interface (n=1) interactions of any type across the two videos from the participants. Of the six learner-learner interactions, all were collaborative problem solving and came from three teachers' classes. Of these six learner-learner interactions, five were in face-to-face instruction, and one was from hybrid instruction.

Due to the low numbers of learner-learner and learner-interface, only learner-content and learner-instructor were included in the next analyses. There was a significant association between the type of instruction and semester ($\chi^2(3)=246.57$, $p<0.001$). This suggests teachers provided more interactions in the spring of 2021 than in the fall of 2020. Interestingly, though there were more interactions in the spring of 2021, there was no significant association between the semester and interaction type ($\chi^2(1)=0.057$, $p=0.811$). Therefore, teachers provided the same types of interactions during the entire year, so there were no differences in instances of learner-content and learner-instructor interactions. There was also no significant association between the type of instruction and interaction type ($\chi^2(3)=2.873$, $p=0.412$). This means that teachers provided the same types of level 1 interactions regardless of the mode of delivery.

Looking at the learner-instructor interactions (n=1459), there was a significant association between the type of instruction and level 2 interaction types ($\chi^2(24)=121.638$, $p<0.001$). This suggests differences in the type of specific interactions based on the mode of instructional delivery. First, students had minimal opportunity to engage in inquiry, justification, or social interactions across all modalities, as evidenced by having percentages less than five. The percent of interactions of cognitive task engagement was similar for face-to-face (38.9%), hybrid (36.7%), and synchronous online (35.3%), but lower for pre-recorded videos (22.2%). Teachers engaged in explanations more frequently in face-to-face instruction (10.0%) than in the other modalities. Further, the percentage of expository interactions was the highest for pre-recorded videos (55.6%) and similar for face-to-face (21.4%), hybrid (28.8%), and synchronous online (28.0%). Finally, pre-recorded videos had the most procedural interactions (14.3%), followed by synchronous online (8.2%).

Similarly, of the learner-content interactions (n=496), there was a significant interaction between the type of instruction and Level 2 interaction types ($\chi^2(9)=99.842$, $p<0.001$).

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Confirmation, or checking work, was most prevalent in pre-recorded videos. In fact, 25% of the learner-content interactions for pre-recorded videos were teachers having students confirm correct answers. No pre-recorded video had students conjecture. However, conjecturing was present in hybrid (28.2%), face-to-face (47.0%), and synchronous online (67.0%). Teachers very rarely had students make predictions, there was only one such learner-content interaction, and that was on a pre-recorded video. Finally, students solved a problem most often in hybrid or pre-recorded instruction (70% for each) but also had opportunities to solve problems in face-to-face (50.2%) and synchronous online (29.9%) instructional settings.

Conclusion

In this study, teachers tend to prefer to engage students in their classrooms via learner-instructor interactions. This is shown through this interaction mode utilized in 74.31% of the interactions. However, teachers also tended to rely heavily on asking questions about the material, lecturing, and answering student questions. This implies that teachers utilize whole class interaction patterns such as the I-R-E (initiation-response-evaluation) (Vogler et al., 2018), where they provide information to solicit a response, receive a response from the student, and then react to those responses to either offer more content or ask a follow-up clarification question. This whole class interaction model requires real-time feedback not available during pre-recorded lessons. The significant association between the type of instruction and the level 2 learner-instructor interaction types reflects that teachers utilized specific methods to cater to the modality of instruction. Teachers could not enact the whole class interaction patterns when using a pre-recorded video, so they relied heavily on exposition to convey information. Alternatively, once students could interact in real-time with teachers, students' responses were evaluated through explanatory interactions. Not being able to interact directly with students also probably led to an increase in having to provide procedural interactions so that the students could navigate the course materials and remain aligned with the course schedule. Once teachers and students occupied the same space, procedural interactions were less commonplace.

Though whole class interactions are a common practice, there were deviations in a quarter of the interactions to promote a more student-centered approach. Teachers allowed students to engage in the content to either perform mathematics (solve a problem 52.02%) or articulate an opinion about the nature of the content (conjecture 44.15%). While these interaction types were prevalent, there were still significant differences based on the type of instruction. There were more interactions focused on students generating correct answers in pre-recorded videos and fewer interactions focused on formulating opinions or conclusions.

While differences in the interactions that took place when teachers were teaching online or in a hybrid format were noted, future research is needed to understand better why teachers made the choices they did when teaching in these different settings. Several factors may have contributed to these differences - local policies, familiarity with technology, professional development, beliefs about mathematics teaching, time to transition courses to an online environment, and classroom management concerns, to name a few. Answers to this question may enable mathematics teacher educators to better prepare prospective and practicing teachers to support students' engagement through different types of interactions while learning online.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1852837. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

Battalio, J. (2007). Interaction online: A reevaluation. *The Quarterly Review of Distance Education*, *8*(4), 339–352.

Campbell, P. B., & Storo, J. (1996). Reducing the distance: Equity issues in distance learning in public education. *Journal of Science Education and Technology*, *5*(4), 285–295. https://doi.org/10.1007/BF01677125

Chou, C., Peng, H., & Chang, C.-Y. (2010). The technical framework of interactive functions for course-management systems: Students' perceptions, uses, and evaluations. *Computers & Education*, *55*(3), 1004–1017. https://doi.org/10.1016/j.compedu.2010.04.011

Corso, M. J., Bundick, M., Quaglia, R., & Haywood, D. (2021). *Where student, teacher, and content meet: Student engagement in the secondary school classroom*. 13.

Garrison, D. R., & Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: Interaction is not enough. *American Journal of Distance Education*, *19*(3), 133–148. https://doi.org/10.1207/s15389286ajde1903_2

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research*, *17*(4), 397–431. https://doi.org/10.2190/7MQV-X9UJ-C7Q3-NRAG

Hillman, D., Willis, D., & Gunawardena, C. (1994). Learner-interface interaction in distance education: An extension of contemporary models and strategies for practitioners. *American Journal of Distance Education*, *8*(2), 30–42.

Hirumi, A. (2002). A framework for analyzing, designing, and sequencing planned elearning interactions. *Quarterly Review of Distance Education*, *3*(2), 141.

Lin, C.-H., Zheng, B., & Zhang, Y. (2017). Interactions and learning outcomes in online language courses: Online interactions and learning outcomes. *British Journal of Educational Technology*, *48*(3), 730–748. https://doi.org/10.1111/bjet.12457

Moore, M. G. (1989). Editorial: Three types of interaction. *American Journal of Distance Education*, *3*(2), 1–7. https://doi.org/10.1080/08923648909526659

Offir, B., Barth, I., Lev, Y., & Shteinbok, A. (2003). Teacher–student interactions and learning outcomes in a distance learning environment. *The Internet and Higher Education*, *6*(1), 65–75. https://doi.org/10.1016/S1096-7516(02)00162-8

Vogler, A.-M., Prediger, S., Quasthoff, U., & Heller, V. (2018). Students' and teachers' focus of attention in classroom interaction—Subtle sources for the reproduction of social disparities. *Mathematics Education Research Journal*, *30*(3), 299–323. https://doi.org/10.1007/s13394-017-0234-2