A case for whole class discussions: Two case studies of the interaction between instructor role and instructor experience with a research-informed curriculum

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This paper presents case studies of two instructors implementing a research informed multivariable calculus curriculum. The analysis, structured around social constructivist concepts, focuses on the interactions between the roles of the instructor in facilitating student discussions and the instructors' experiences with the activities. This study is a part of an effort to evaluate and improve the project's effectiveness in supporting instructors in implementing the activities to promote rich discussions with and among students. We find these instructors to be focused on their roles as facilitators for student-centered small-group discussion and that they choose not to have of whole class discussions. We argue that initiating whole class discussions would address concerns and negative experiences reported by the instructors.

Keywords: Multivariable calculus, Active engagement, Instructor roles, Whole class discussions

The *Raising Calculus to the Surface* (RC) project uses physical manipulatives, group work, and open-ended questions to encourage students to discover multivariable calculus concepts and use different representations of multivariable functions. During lab activities, the materials are designed for the instructor to move between two roles: (a) acting as a **small-group discussion facilitator** or questioner to help students within a group resolve difficulties, and as a (b) **whole-class discussion facilitator** to help the whole class together engage in meaningful discussion about the newly discovered concepts. As a small-group discussion facilitator**,** instructors do not inject content, but by asking questions, they help groups move toward meaningful discoveries while maintaining the group's autonomy and ability to struggle meaningfully. As a whole-class discussion facilitator, the instructor shapes the discussion productively by prompting students with important questions and ideas.

In contrast to the instructor's roles of lecturer, question answerer, or answer checker, the instructor's role in these activities often requires much less active talking. This is sometimes a challenge for instructors to adopt, in part because it is so easy to focus on only one role instead of moving between roles and is uncomfortable for some lecture-first instructors. The project includes several support mechanisms for instructors, including (a) a training workshop, (b) an instructor's guide, and (c) an online support website. This paper explores the implementation of RC materials by two instructors in order to better understand how the project team can support instructors in having rich discussions with students in group and whole-class discussions.

Theoretical Perspective and Methods

Theoretical perspective

Our overall research, similar to active-learning research studies, is structured around social constructivist concepts (Ernest, 2010; Vygotsky, 1978 & 1986). This conceptual lens regards individuals and their learning environment as an interconnected unit where learning of an

individual occurs both in sociocultural activity and in the mind of individuals. With this perspective in mind, all class interactions (group work, instructor communication and interaction, etc.) play an important role on the students' development of mathematical concepts. Students' in-class engagements on tasks with more knowledgeable and capable others such as the instructor and peers help them develop the mathematical concepts through communication. Thus, it is important to focus on instructors' interaction and the ways in which they communicate with their students.

In this paper, we specifically focus on how instructors enact discussions with students during student-centered activities. Both personal characteristics (e.g. knowledge of different teaching strategies and beliefs about how to support student learning) (Ball, et al., 2008) and situational factors (e.g. expectations of content coverage, class size and room layout) (Henderson and Dancy, 2007) influence such actions.

Methods

Data for this paper were accumulated from pre/post surveys for two instructors, Rickie and Janos, about their participation in the project (summer 2014, December 2014, and spring 2015 if implemented a second time), a post-survey about the training workshop (summer 2014), electronic weekly reports submitted by adopting instructors (fall 2014 and spring 2015), an evaluation interview (summer 2015), and some student data. The instructor data are in the form of responses written by the instructors on surveys and reports, an audio recording and transcript of Janos's interview, and detailed notes from Rickie's interview (no recording was made). The student data are written work and audio recordings of student groups in Janos's class working on an activity and scanned copies of Rickie's students' activity worksheets. The pre/post surveys included items about the instructors' attitudes and beliefs about student learning in multivariable calculus and items about practices. The interviews were semi-structured and included logistical questions about how the activities were used and reflection questions about how the activities went and the instructors' opinions about the geometric and contextual features of the activities.

The authors surveyed the corpus of data and took notes on information interesting to the RC project. The authors revisited the data and took additional notes focusing on how the instructors' implemented the activities and how the instructors supported and managed students' discussions. These notes were used to create descriptions of the instructors' implementation of the activities and how they supported and managed discussions during the activities.

Both instructors have characteristics for adoption: they both voluntarily chose to adopt the activities, attended an off-site training workshop, describe themselves as valuing active learning, and have in the past used active learning classroom strategies apart from the RC materials. Additionally, they both have been/are participants in a professional organization which focuses on helping mathematicians grow professionally in their early years in a tenure-track position. We choose to highlight these two instructors because, despite these commonalities, the role of the instructor in these implementations was conceived of and put into practice differently. In examining these two cases, we hope to understand how to support instructors in facilitating productive discussions across a variety of implementations.

The descriptions presented here are not an attempt at a comprehensive picture of these instructors' experiences in implementing the activities. They are focused on one aspect of the implementation: the instructors' roles during the activity in facilitating student discussions.

Additionally, these instructors were not selected to be representative of the average adopting instructor, but rather to illustrate a range of instructors included in the project.

Descriptions of Implementation for Two Instructors

Rickie teaches at a large public Master's-granting university, used the project materials in two sections of multivariable calculus in Fall 2014 and another two sections in Spring 2015. He was able to attend the full workshop, had previously taught multivariable calculus at his home institution for multiple semesters, and incorporated the project materials in both fall and spring terms with two sections each semester.

In contrast, Janos teaches at a medium private Ph.D.-granting university and used the project materials in one section of a third-semester calculus course. Janos attended only the first three hours of the nine hour workshop, had a curriculum mismatch with the project materials (multivariable functions were introduced in the previous, second semester calculus course), and hence chose to implement the materials on the last day class.

Implementation by Rickie

Rickie initially attempted to change his instructional practice to a more student-centered approach by attempting to "not talk" to the entire class and to not provide answers to students. He then expressed frustration at students missing opportunities to discuss important aspects and not reflecting on their answers. He modified the student worksheets to prompt these discussions/reflections. At the end of the second semester, he reported that he highly valued the active, social nature of his class as a result of using the activities, consistent with student-focused approach, but wished the worksheets contained extension questions that challenged students to reflect on their answers.

The curriculum is designed for students to discover mathematical content in small groups, prior to lecture. This process often requires that instructors give students the space to make and correct mistakes. Rickie conscientiously attempted to achieve this goal. After implementing the first activity, Rickie wrote that "I focused as much as possible on not talking. That is obviously difficult" (weekly report, 9/1/2014). When asked what went well in the first activity, Rickie wrote "Letting them take over their own learning. Good prep for the next lab" (wr, 9/1/2014). When asked what could have gone better, Rickie said "Too little of me helping each group. I have 9 groups making it very tough to always help. Or prompt" (wr, 9/1/2014). We interpret these comments as meaning that Rickie felt the groups generally needed assistance from him to be productive, but that he was trying to give students space to explore by not addressing the entire class and providing explanations, or "not talking," an unnatural instructional mode for him. He mentions "not talking" in his reports of the first two activities in both semesters.

The instructor expressed a desire for students "to have someone in the group question responses that were incorrect" (wr, 1/17/2015). Students are not likely trained in this 'cynic' role, but it is an important part of authentic mathematical practice. The instructor can model this by prompting or promoting student discussion during either small-group discussion or whole class discussion. By doing it with the whole class, all of the students can see how this role contributes to and shapes the discussion.

In his evaluation interview, Rickie also noted that he particularly valued the wrap-up questions on the student worksheets which challenge students' new understandings of

mathematical content. On the second activity, a wrap-up question intended to create a two-sided debate between students based on relying upon (or not upon) their intuition. Done in the whole class, this question provides the instructor multiple students for each side who can argue using knowledge gained from the activity. By putting the question on the activity sheet, Rickie gained an ability to address issues with students at their pace at the small-group level. He altered the question to address the conflict between the surface's height referring to lead level and not elevation. He diverted a whole class discussion into a small group discussion. This decision removed opportunity for students to contribute to the class's collective understanding. Rickie expressed a desire to offload whole class discussions onto the worksheet on several occasions.

One benefit of employing whole-class discussion is it offers flexibility to instructors during the activity. Rickie noted on the fourth activity in the fall semester that "I think if at least one of the pos[itive] x or pos[itive] y direction was such that the slope was negative, the activity would have more 'bang' to it in terms of discussion" (wr, 9/27/2014) He also noted that "A question like 'where should you draw the gradient vector...on the surface or on the grid paper'? Do it. Why? might be nice. Better yet, have them do it on the contour map for that surface" (wr, 9/27/2014). Rickie provided this constructive feedback to the project as a way to improve the activity sheet. Mathematically, specific scenarios like the first suggestion described above cannot be guaranteed. Hypothetical questions on an activity sheet are confusing; such questions fit better in discussion. The whole class discussion allows students with different surfaces and different scenarios to share their work and find the common mathematical ideas common across cases. This sharing of knowledge across groups helps focus students on underlying math content, not studying their specific surface.

In the post-course survey, Rickie notes the project's impact on the classroom and student learning: "The social interactions are much improved in my mind. The early labs really help break the ice and make the class more lively (both during class and after hours). That alone is worth consideration for continuation" (2nd post survey, spring, 2015).

Implementation by Janos

In a manner similar to Rickie, Janos "spent most of my time answering their [the students] questions" (weekly report, 12/8/2014) in small groups and did not engage the students in a whole class discussion.

Janos worked diligently to help students address their concerns and understandings during the class period, consistent with the intended small-group discussion facilitator role described above. Audio recordings of student group discussions revealed that the instructor had meaningful discussions with students and used questioning techniques with students. He noted that as a result, "I was exhausted by the end of the class!" In a separate part of the report, the instructor noted "Running this activity took a lot of energy and I could not get to each of the seven groups quick enough" (weekly report, 12/8/2014).

We believe two aspects of the implementation contributed to the fatigue reported by Janos: focusing on his small-group discussion facilitator role and inadequate preparation (reported by the instructor). First, when moving between student groups, an instructor will encounter the same student difficulties/questions several times. Another strategy would be for the instructor to orchestrate a whole-class discussion when encountering questions/difficulties common to several student groups. This strategy has several advantages, including being more energy efficient for the instructor, providing opportunity for students in other groups to suggest or share resolutions

to difficulties (promoting student authority), and allowing for a common language and consensus to develop among the groups (engaging in authentic mathematical practice).

Second, Janos used a lot of intellectual energy addressing students' questions. He reported instances of not being quite sure about how to address some of the students' questions and attributed this to a lack of preparation on his part. "I feel like I should have read the instructor [guide]. I thought that going through it once with my advanced physics kids would be enough but, um, it wasn't. I should have--later, after it happened, I went and I looked at all the different material and I thought, 'Oh, I really should have read this' because **…** they [the researchers] saw … common students' responses and questions, and those definitely came up [in my class]." (evaluation interview).

Janos mentioned having a really interesting conversation while practicing with two former students in preparation for class. He attributes the opportunity for this to happen to his role as a more equal member of the group. "I remember we started talking about functions and '1:1' and 'onto', I think that's what it was--and inverses, but with respect to, you know, in three space. And, I thought that was a really interesting conversation I had with them because it was like the three of us were in a group together, working on this together, you know. I wasn't acting like the professor guiding them; I was learning with them … but that conversation did not come up in class in any of the groups that I witnessed… I think that if … we had someone IN each group… who can kind of guide the conversation then it might have gone there, but since I was bouncing around...I wasn't able to really spend that deep time with any of the groups" (evaluation interview). One possible way to address this facilitation challenge is to allow time for a whole-class discussion. In a whole-class discussion, the instructor can participate as a more equal member of the class than when moving from group to group where his participation in each group is necessarily transient.

Discussion and Questions

These case studies describe instructors who focus on the role of small-group discussion facilitator and do not facilitate whole-class discussions. The case studies above include instances where having a whole-class discussion may result in less work for the instructor and increase opportunities for all groups to participate in important discussions. Although the workshop modeled whole class discussions and the instructors guides provide support for instructors to conduct whole class discussions, these cases suggest that this support does not go far enough. It seems that these instructors may have ideas about student-centered instruction, or about the specific RC curriculum, that do not include a role for whole class discussions. Given this backdrop, we ask the following questions:

a. What aspects of a training workshop can support instructors in initiating and moderating whole class discussions?

b. What kinds of instructor discourse promotes student autonomy in whole class discussions?

c. What impact do whole class discussions have on student learning and mathematical practices in student-centered curricula?

References

Ball, D. L., Thames, M. H. , and Phelps, G. (2008). Content Knowledge for Teaching: What Makes It Special? Journal of Teacher Education November/December 59: 389-407

Ernest, P. (2010). “Reflections on Theories of Learning” in B. Sriraman and L. English (eds.) *Theories of Mathematics Education* (pp. 39-47). Springer Berlin Heidelberg. doi:10.1007/978-3-642-00742-2

Henderson, C., & Dancy, M. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics - Physics Education Research Phys. Rev. ST Phys. Educ. Res., 3*(2), 020102-020116. doi:10.1103/PhysRevSTPER.3.020102

Vygotsky, L. S. (1978). Interaction between learning and development. From Mind and Society (pp. 79-91). Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1986). Thought and language. Newly revised and edited by Alex Kozulin. Cambridge, MA: The MIT Press.