Using research problems rather than research questions to aid working across disciplines

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This paper discusses a methodological tool called research problems as a way of working and communicating across disciplines. The two kinds of research problems considered are inertia problems and blockages. These problems are used in concert with selected philosophical concepts from Deleuze and Guattari and form the starting point of a methodology developed in a PhD dissertation. The choice of philosophical concepts was strategic as its new materialist influence may aid researchers in thinking in new ways beyond the strong influence psychology has had in mathematics education over the past several decades. This methodology is specifically aimed at designing and implementing technological interventions in mathematics education settings. Ultimately, the research problems approach is offered as a basis for a type of inquiry that is experimental, rigorous, and capable of capturing unexpected outcomes.

Method, multidisciplinary approach, mathematics education, educational research, philosophy

Introduction

The mathematics teacher's day is now full. This assumption forms the basis of the method and concepts outlined in this paper. Simply put, if researchers want to pilot a technological intervention in a mathematics classroom then the intervention should either optimise something the teacher is already doing thereby making more time available for the teacher; or, the researchers need to state which other practice of the teacher should be sacrificed to make room for the intervention. This paper discusses two types of research problems designed to help researchers from different disciplines share common reference points while respecting the specific context, capabilities and thresholds of a given classroom.

Rationale

The overarching rationale for proposing a research problems approach is that technology is fundamentally changing the classroom experience for teachers and students, and its new capabilities and potentials need to be investigated experimentally yet rigorously. For instance, the internet has become a staple of most schools and has, in a sense, started to dissolve the classroom (Borba, Clarkson, & Gadanidis, 2012); and so, it is posing new questions about what mathematics education *might* look like.

However, even though technology is being integrated into schools and classrooms, it is still largely being used to sustain old practices (Cuban, Kirkpatrick, & Peck, 2001). As a research community, we might profit from concepts that shift ways of thinking away from what should be done, to what might be possible.

Correspondingly, Borba et al. (2012) recommend while research methods should not lack rigour, they should be able to capture unexpected outcomes.

Finally, while the field of mathematics education has often profited from new theories and philosophies outside of its domain (Sriraman & English, 2010), it must take seriously a call for “systematic communication between theories that would go beyond merely borrowing” (Sriraman & Nardi, 2012, p. 321). The research problems approach proposed here, along with its methodology, is offered as a practical way of experimenting with rigour, capturing unexpected outcomes, and aiding communication between theories.

Influences and Positioning

The two research problems discussed here comprise one part of a three-part methodology developed in a PhD dissertation (Sutherland, 2018). The method was designed to develop and implement technological interventions in mathematics classrooms. The main philosophical influence was a book called A Thousand Plateaus: Capitalism and Schizophrenia (Deleuze & Guattari, 1987). While this work offers numerous useful philosophical concepts—like ‘assemblage’, or ‘lines of segmentarity’—applied to a vast literature base, it is unfortunately dense and written in a style described as “almost offensively obtuse” (Young, 2013, p. 3). Substantial reading of numerous other primary and secondary sources was required before any of the concepts could be used with some degree of confidence. Additional reading was also done in complexity sciences, sociology, systems theory, artificial intelligence, and other authors using Deleuze and Guattari in Mathematics Education or more broadly in the social sciences (e.g. De Freitas & Sinclair (2014), Lather & St Pierre (2013), and Roth (2010)).

This philosophical influence of the methodology is often called a new materialism and this work is difficult to position in relation to more familiar epistemology and ontology in mathematics education. Specifically, this specific method complicates common assumptions held in quantitative and qualitative fields of inquiry. To contrast complex and quantitative assumptions, consider that one core assumption of a complex method would be that of an open system rather than a closed system. This means it is not possible to isolate certain elements that comprise the essence of a phenomenon and stable relationships among these elements. Specifically—and in stark contrast to empirical methods—it is assumed that any element in an open system can have an influence ranging from large to negligible (Heylighen, Cilliers, & Gershenson, 2006).

Deleuze and Guattari’s relationship with qualitative methodologies is harder to pin down. New materialist work significantly complicates assumptions about rationality, representation, data, interpretation, and subjectivity which ultimately seems to make these two forms of inquiry irreconcilable. Ultimately, I would position inquiry using research problems closer to complex methods but with a stronger emphasis on philosophical concepts in design, implementation, and documentation.

Research problems

The research problems approach is influenced by Deleuze and Guattari’s work though it is worth seeing how each author defines problems. For instance, Deleuze has a broad definition of problems in that it brings about a frustration with the status quo and so “forces us [to] search [and] robs us of peace” (Deleuze, 2000, p. 15). Guattari, on the other hand, situates problems more specifically within the social realm and borne from his frustration with institutions like schools, trade unions, political parties, and research groups because they were "prone to the problems of rigid hierarchizing, segregation, and inertia" (Watson, 2009, p. 22). I have appropriated these two views into what I call research problems, specifically two kinds of problems namely inertia and blockages. These two types are by no means exhaustive or the final words on what constitutes research problems.

These two types were defined in terms of tendencies that people from different disciplines can agree on reasonably easily, especially in agreeing on whether an intervention is inertia prone or blockage prone. Inertia problems broadly refer to any kind of routine or norm in a classroom that would perish without a continuous investment of energy, like continuously trying to get as many students as possible involved in discussions. Blockages refer to a traffic-jam-like dynamic where the amount of work generated for the teacher overtakes the teacher's capability to deal with it. These two problems are used in concert with philosophical concepts from Deleuze and Guattari that emphasize the capabilities, interactions, thresholds and potential emergence of some mathematics classroom or given context.

Problems of Inertia

An inertia problem is like a marble in a bowl where the state of having the marble swirling around in the bowl is valued above it resting at the bottom because of a lack of energy or shooting out of the bowl because of too much energy. In a classroom, if discussions between the teacher and the students—or among the students—are valued then the teacher must continuously invest energy into encouraging various students to participate. If the teacher abandons this investment, then the sociological tendency comes into play where fewer students tend to speak over time. If only three or four students out of 30 tend to speak in a classroom, then this would be a state of inertia though not completely inert.

In mathematics education, Smith, Hughes, Engle, & Stein (2009) value students engaging in "cognitively challenging mathematical tasks" (p. 549) which in turn elicits diverse responses and strategies from students. These diverse responses can then be orchestrated into productive discussions using their five practices of anticipating, monitoring, selecting, sequencing, and connecting these diverse student responses. The five practices were used in the study (Sutherland, 2018) as a way of countering this inertia by engaging more students in discussion by using an online feedback application. In this way, partial strategies and common misconceptions could also be sequenced into the discussion, allowing students to participate and be made to feel valued even if they did not know the answer. This was a useful way of countering inertia while giving students opportunities to learn and discuss their strategies. However, care had to be taken to avoid a blockage by creating too much work for the teacher.

Blockages

A blockage is like a traffic-jam: more cars are entering a section of a highway than there are cars leaving it, so it creates a slowing down or even a gridlocking of cars. This tendency is reasonably simple to identify and agree upon by people from different disciplines. Two such observers may even agree on a specific threshold or rate of cars entering to cars leaving that could be classified as being in a state of jamming versus being in a state of gridlocking. More generally, there are similar tendencies in a variety of phenomena e.g. a beehive, a server of a popular website, a food stall, or visa-applications at an embassy.

In this intervention, the blockage problem seemed to share a fate with inertia problems in that an initiative aimed at countering inertia might often end up reaching a blockage and ultimately failing—or collapsing—because of it. For example, say a teacher decides to let each student write a paragraph on paper about their thinking regarding the slope of a line. This is repeated for all five of her classes and creates a workload of 140 paragraphs which costs the teacher an additional 30 minutes per day. This initiative soon collapses because the workload created to counter inertia ended up creating a blockage.

In this way, it is possible to define potential thresholds—like not creating more than five minutes of additional workload—which may prompt a researcher to pay more attention to a specific teacher and her context. The online feedback application used in the study was iteratively designed and improved using metrics like workload, class size, and internet connectivity. Capabilities and thresholds like these created a useful framework for comparing different contexts. Interestingly, one of the classes in the United States had more in common with a classroom in South Africa than it did with the classroom next-door to it based on its Wi-Fi connectivity and the practical implications that had for the intervention.

Events, thresholds, collapse and emergence

As mentioned previously, this method involving research problems is heavily influenced by the philosophical concepts of Deleuze and Guattari. The two concepts chosen were assemblage and lines of segmentarity and the reader is directed to Sutherland (2018) for a discussion of each. For the purposes of this paper, suffice to say that these concepts are used in the same way that a complex methodology might choose principles according to its requirements and context.

The important difference here is that the new materialist concepts are more process oriented and less reliant on empirical or structuralist tendencies. There is a greater focus on experimentation and potential connections, interactions, feedback loops, capabilities, thresholds, and emergence rather than interpretation of phenomena, finding ideal instances, or codification of data. Finally, I recommend these concepts as a way of stimulating thinking outside of the artificially circumscribed research areas and tendencies created by a long relationship mathematics education has shared with psychology and—arguably—an over-reliance on its theories and philosophies (Sriraman & English, 2010).

To oversimplify, an intervention would be considered successful if the teacher continued with the practice after the study completed. If the teacher did not continue with the practice, then special attention is paid to moments of collapse and the contributing context. In either case of emergence or collapse, the context and intervention are documented with a focus on capabilities, thresholds, emergence, or collapse. For example, statements might include: *All students need access to Wi-Fi, and the initial set-up must take less than 20 minutes. The student feedback application did not work where there were less than eight students in a class. In cases where the teacher continued to make use of the application, she became more aware of student misconceptions.*

In other words, this method is not about attempting to replicate an end product but rather it is focused on iterating a process in a similar context and then documenting the resulting variation. Finally, the method is also sensitive to unexpected events which can be documented and shared with other researchers to open new potential lines of inquiry. For example, one of the maths teachers in the original study ultimately stopped using the application in his mathematics class and ended up using the application more for supporting his baseball athletes' academic needs.

A metamodel

When working with people from various disciplines, it may often be useful to find some way of communicating using some common diagramming practice, or "conscription device" (Williams et al., 2016, p. 12). For this purpose, I have proposed a metamodel, shown in Figure 1, combining the research problems approach with the philosophical concepts in a way that is not discipline specific. Figure 1 shows a spiral towards an inertia point, representing the number of participating students decreasing over time. The star represents some events initiated by the teacher to counter this tendency. This event has a short, or 'supple', existence before it either collapses back onto the inertia-prone status quo or onto a new classroom practice, or 'line of flight'. In other words, the focus is on whether an intervention added some new consistency to the classroom or collapsed back onto the status quo. Additionally, specific capabilities, thresholds, and connections are documented to allow other researchers access to potential pitfalls and opportunities in their own domains of research.

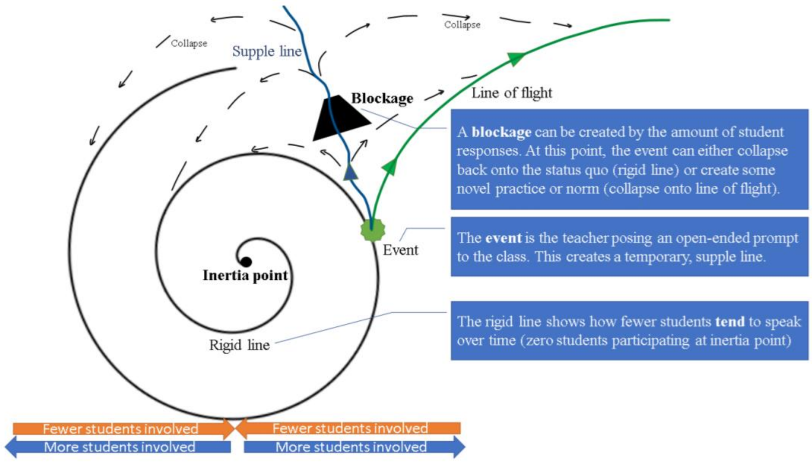

Figure 1: A metamodel for discussion inertia and blockages

Conclusion

Research problems are offered as a basic frame of reference for researchers working across several disciplines. And, when complemented with philosophical concepts like those of Deleuze and Guattari, a technological intervention can be parameterised regarding capabilities, thresholds, collapse and emergence. This in turn opens more avenues of experimentation by connecting different capabilities within tested thresholds and allows for the capturing of unexpected outcomes. Within this framework of problems and philosophical concepts, the original study was able to productively use theories from across mathematics education literature, complexity, sociology, and software engineering. It is hoped that this methodology will allow researchers to compare and perhaps even combine their studies—using concepts like capabilities and thresholds—with other studies based on shared research problems without being required to necessarily share ontological or epistemological commitments.

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