Inquiry-based learning in mathematics:
Negotiating the definition of a growing pedagogy

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Abstract: Inquiry-based learning is one of the pedagogies that has emerged in mathematics as an alternative to traditional lecturing in the last two decades. There is a growing body of research and scholarship on inquiry-based learning in STEM courses, as well as a growing community of practitioners of IBL in mathematics. However, despite the growth of IBL research and practice in mathematics, wide uptake of IBL remains hamstrung in part by the lack of a sophisticated discussion of its definition. Using a diffusion and framing analytical framework, this qualitative research paper offers a first step toward addressing this problem by describing how a group of IBL practitioners define IBL and how they adopt IBL to fit their specific teaching needs. We argue that early diffusion of IBL, for the group we studied, was constrained by the initial framing of the pedagogy and ongoing conflict over the proper definition and application of it in the classroom. Over time, however, the conflict proved to be beneficial to the community and a general consensus is developing among practitioners of IBL focusing on two core beliefs: 1) that it is only IBL if the student takes ownership of course material on a regular basis, and, increasingly, 2) that students collaborate as a class or in small groups to produce the mathematics.

Introduction

Calls to evaluate and reform undergraduate teaching in higher education have been commonplace since the 1980s (Boyer, 1980; Brint, 2011; NGA, 1986), and in the discipline of mathematics these efforts have been particularly urgent (MAA, 1988; NSF, 1993; NRC, 1991; Tucker & Leitzel, 1995) because of the central role of mathematics in both general education and preparation for careers in technical and scientific fields. However, the literature suggests that reforms often result in minimal, lasting change. Research focusing on higher education writ large suggests that reforms are ineffective because of the challenges faculty experience in balancing their teaching and research roles (Cuban, 1999), because an emerging consumer-centric culture surrounding higher education has prevented reforms from influencing student achievement (Brint, 2011), and because faculty themselves have little reason to change given disciplinary cultures (Abbott, 2002) and institutional incentive structures. For reform in STEM fields specifically, research points toward poor implementation or the lack of quality collaboration and communication between curriculum researchers and instructors as additional reasons for sluggish adoption of innovations (Henderson & Dancy, 2008; Henderson, Finkelstein, & Beach, 2010).

Inquiry-based learning is one of the pedagogies that has emerged in mathematics as an alternative to traditional lecturing in the last two decades. There is a growing body of research and scholarship on inquiry-based learning in STEM courses, as well as a growing community of practitioners of IBL in mathematics. In the late 1990s, the Educational Advancement Foundation founded the Legacy of R. L. Moore annual conference, which began as an effort to spread the specific teaching method of the late topologist R. L. Moore but has become a focal point for a group of young instructors who identify themselves as IBL practitioners. In 2009, the Academy for Inquiry-based Learning was developed to foster further growth of the community through its blog, list serves, and workshops (www.inquirybasedlearning.org). However, despite the growth of IBL research and practice in mathematics, wide uptake of IBL remains hamstrung in part by the lack of a sophisticated discussion of its definition. This paper offers a first step toward addressing this problem by describing how a group of IBL practitioners define IBL and how they adopt IBL to fit their specific teaching needs.

Analytical Framework

This paper defines IBL as an educational innovation and thus our analytical framework utilizes perspectives and concepts from the literature on the diffusion of innovation. One of the central features in diffusion theory is the extent to which individuals can positively identify with an innovation. In this study, positive identification emphasizes the presence of shared understandings of IBL within the IBL community and this is important for both the diffusion of the innovation to potential members and the ongoing use of the innovation by existing members.

Rogers (2003) argues that an innovation is more likely to successfully diffuse if it meets several criteria: it has relative advantage over alternative courses of action, it is consistent with the values, experiences and needs of potential adopters (what Rogers refers to as "compatibility", see also Givan, Roberts, & Soule, 2010 on "theorization"), it is not too complicated for the average potential adopter to understand and implement, it is something that can be adopted to specific circumstances, and it is relatively easy for potential adopters to observe in action. The criteria of compatibility with individual values, experiences, and needs and the perception of the fit of the innovation to individual circumstance are particularly relevant to our concern about identification with the change process. For all of these criteria, the perceptions of potential adopters about the innovation are crucial, and these can be particularly influential when potential adopters form opinions and make decisions that influence whether they will even consider trying an innovation.

Individuals, then, will be more likely to adopt an innovation if 1) they already identify with the innovation in some capacity, 2) they identify with the definition of the problem that is addressed by the innovation, and 3) they feel they will benefit from adopting the innovation because the proposed changes fit their needs and circumstances. This focuses our analysis on how different individuals define IBL in mathematics, how they identify the problem addressed by IBL, and their perceptions of how they perceive it to fit (or not) their specific needs.

Central to the ability of individuals to connect to innovations is the issue of discursive framing, or what Strange and Soule (1998) call "interpretive work." Discursive framing refers to the ways that various discourses are used by different groups to frame an innovation's purposes, values, and actions. In many cases, individuals who seek to diffuse innovations must negotiate their own multiple understandings and identities related to an innovation itself and the understandings of it projected by other innovators (see also Givan, Roberts, & Soule, 2010). This cultural work, establishing the boundaries of key concepts and what it means to be a member of the group of innovators, is a dynamic, ongoing process. Taken together, this analytical framework focuses our attention on how the faculty in our study define IBL, how they interpret and enact it in practice, and how they perceive their perspective to fit into their broader understanding of the IBL community.

Methods

Data for this paper were gathered primarily through semi-structured interviews that took place over the telephone or occasionally in person. We strove for a conversational style in the interviews rather than a simple question and answer approach (Burgess, 1984; Seidman, 2006). For the purpose of our project, we defined the IBL community as the group of practitioners who attend and are connected to the annual Legacy of R. L. Moore conference. We used knowledge of the community gained from past-research and evaluation projects to identify a preliminary list of the core members based on current and past involvement in putting together IBL workshops or participating in the organization of the annual conference. Additional names were added to the list through the use of snowball sampling as data gathering unfolded (Merriam, 1998; Mason, 2002). Potential interviewees were sent a solicitation email providing them with background information about the study and how their interview would contribute to it. The majority of interviews were 60-90 minutes in length, were digitally-recorded and transcribed verbatim. These interviews covered a variety of topics related to instructors' knowledge of the history of the IBL community, how they defined and applied IBL in their own courses, their perspectives on the values and shared behaviors of the IBL community, and their hopes for the future of IBL. This paper is based on 25 such interviews with mathematics instructors at institutions across the United States.

These interviews were transcribed and coded using the data analysis software *Nvivo 10*. The coding process was informed by Miles and Huberman (1994), particularly the strategies of pattern coding, clustering, identifying intervening variables, and making conceptual coherence. The first stage of coding utilized concepts from the diffusion literature. Initial codes were developed based on how speakers defined IBL (what it is and is not), and how they have reinvented or adapted it to fit their various teaching needs. Secondary coding schemes were developed through analysis and exploration of the patterns in the relationships between different clusters of the primary coding data.

Additionally, we made use of an open-ended survey item from a past study of this community that asked respondents to define IBL. As this survey sampled a broader group, the survey responses provided a necessary and insightful complementary data set that allowed us to

compare and contrast the definitions of IBL for the core leadership group of the community and by members who are more peripheral.

Results

     All of the early adopters we interviewed remembered the last years of the 1990s as a period when they all realized they needed a new generation to join the IBL community. The early adopters are all instructors who were taught by and learned IBL directly from R. L. Moore or one of his academic descendants. Beginning in 2003, these early adopters developed three different programs to reach out to potential members and educate them about IBL: 1) they began a series of annual workshops inviting new people to attend to learn about IBL and network with experienced IBL users, 2) they started four IBL centers in mathematics departments in universities across the United States that taught courses to future mathematicians using IBL and exposed graduate students and post-doctoral fellows to the teaching method, and 3) they connected with the Mathematics Association of America's Project NexT program, which focuses on the professional development of early career faculty in mathematics. Collectively, these three programs successfully exposed a new generation of instructors to IBL by 2010.

     However, this exposure did not automatically translate into widespread diffusion of IBL because of two primary framing-identity problems. First, the pedagogy was intimately connected with the memory of the late R. L. Moore, which linked it to a personality and social perspective that many potential new users find troubling. Moore was a controversial figure because of his racist and sexist perspectives (Parker, 2005, pp. 287-290). Nearly all instructors interviewed acknowledged this fact but there were generational differences in how they negotiated its meaning. Older generations rationalized his social views by emphasizing the culture of the South that surrounded him or by attempting to focus only on his teaching method and ignoring the problematic aspects of his image. This enabled the older generation to maintain a positive identification with IBL. However, younger members of the community were not able to maintain such a positive identification with IBL so easily. Many of these younger instructors discussed the limiting role those social views have on getting some of their colleagues to attend community events. For example, one younger community member spoke about Moore's connection to IBL preventing many potential new members who already had teaching philosophies in line with the group from attending community events like the annual conference.

     [P]art of Moore's legacy is racist, and...there are people who would be on board with
     [our] ideas and wouldn't have any trouble being part of the community at the conference,
     but because his name is still associated with it, sort of on principle, wouldn't consider it.
In attempting to spread IBL to a new generation of instructors, most early adopters failed to recognize the importance of Moore's racism and sexism to the population they were targeting.

     Secondly, the original labeling of IBL as the "Moore Method" and later the "Modified Moore Method" was not ideal, as this framing using a name that is not broadly known in the discipline of mathematics prevented potential adopters from understanding or identifying with the teaching method. In fact, the majority of those interviewed who joined the community after its founding had never heard of the "Moore method" until they heard about the annual conference or encountered someone who was already in the community and realized they were teaching in a similar way. Together, these naming and framing issues made the processes of persuading new users to implement IBL and become active in the community challenging.

     Many of the young faculty who joined the community as a result of the workshops, the IBL centers, or Project NExT expressed feeling out of place the first time they attended the annual conference. One instructor even referred to the culture of the group in the early years as a "cult of personality" surrounding Moore.

There's something about the structure and the history of the group that, for one reason or another has not resonated with everyone, I think. Certainly, it was the case at my first Legacy meeting. It was sort of a cult [of] personality meeting. Everybody talked about R.L. Moore and what a great influence he had had on each of them personally, and what a transformative experience they'd had and how they felt empowered by him.

Another community member from the same generation agreed and offered a stark criticism of the group's culture when he first started.

It was extraordinarily off-putting the way that the older members of the community would talk about their bloodline, their genealogy, their purity, if you will; with whom they studied and which descendant of whom they took courses from.

While the older generation of this community clearly championed the value of their experiences with Moore, or his descendants, and the type of IBL he taught, the ways in which they spoke about their experiences ostracized potential new members. Rather than stop going to the conference altogether or ceasing to use IBL, some of these younger generation members formed their own subgroup that is more welcoming and less Moore-centric in their thinking about IBL. One instructor offered a brief history of these group dynamics.

One of the first few...conferences I went to, it felt like there was a divide. There was this group of people that was really devoutly following Moore and what Moore did and that what he did was very important and it should be preserved. Then there was another group of people who were trying to introduce new ideas, and this was, I feel like this group of people that were open to new ideas, seemed like the minority the first time I crashed the conference. Then, as the years went on, it started becoming the vocal majority, they were the ones organizing.

As the younger generation increased in number and had more influence in community events, their ability to challenge the dominant framing of IBL as connected to Moore increased as well. In contrast to the early group of instructors who identified with Moore-centric definitions of IBL, the growing sub-group of instructors increasingly embraced broader adaptations of the pedagogy.

Once enough new users identified with IBL and adopted it in their own practice, conflict increased between competing visions of how IBL should be labeled and defined. Several instructors, old and new, remembered arguments during paper sessions at the annual conference about the "proper" definition of IBL over the years. For example, one of the central pieces of conflict has been over whether collaboration among students should be considered part of IBL teaching methods. Older adopters stand by Moore's insistence that it is ultimately more empowering if students arrive at answers on their own while newer members argue that collaboration is more comfortable for students and ultimately more effective in today's increasingly diverse classrooms. Furthermore, the community has recently been publicly challenged to move away from an association with Moore altogether in favor of a strategy intended to recruit the faculty that were historically turned away by the problematic connection between Moore and IBL. The complete impact of this discursive move remains to be seen, but it is clear that it has energized the younger majority of the community. However, this relative, and perhaps even temporary victory for this group, took years to develop and was the result of conflict as original members and new members attempted to work through their initial differences in definition and understanding.

Today, though many in the IBL community embrace a much broader framing of the pedagogy, many practitioners are concerned that it is becoming too broad. Over time, as more instructors use IBL methods in their mathematics courses, the group has increasingly realized that it needs to be adapted to fit new circumstances, new groups of students, and new courses. As a result, many early adopters and change agents are concerned about how they police the

boundaries of the pedagogy. For example, the annual conference has recently accepted papers on flipped-classrooms and not all members of the community agree that this is appropriate. Nonetheless, the persistence of instructors with a broader definition of IBL have therefore seemingly won the day by providing the discursive framing necessary for newer faculty to identify with the movement and the pedagogy. The emerging dominant frame is one that avoids ideological connection with Moore and his problematic legacy and instead highlights two core beliefs: 1) that it is only IBL if the student takes ownership of the material on a regular basis, and, increasingly, 2) that students collaborate as a class or in small groups to produce the mathematics. Thus far these core values have been enough to successfully recruit new members in the last few years while also preventing IBL from being too watered down in the eyes of the community.

Conclusions and Significance of the Research

   Results of this study raise important implications for understanding reform efforts in higher education. Arguments for why reforms of teaching are slow to take hold—or die off altogether—focus on well-known contextual issues: that faculty focus on research more than teaching, that changing teaching requires more time than faculty have, or that instructors struggle to adequately implement new curriculum or pedagogy. This study reminds researchers, as well as practitioners, that it is also important how reform efforts are framed by those advocating for them and how potential adopters perceive new curriculum or pedagogy matters. While finding teaching methods that engage students or promote learning is important, researchers and practitioners must frame their innovative reforms in ways that connect with instructors' preexisting identity, values, perceived needs for their students.

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