Constraints for Changing Instructional Approach? WE CAN DO IT!

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Although different instructional models for teaching mathematics have arisen over the past decades, lecturing continues to be the preferred approach of abstract algebra instructors. We identified facilitating and constraining factors of instructional change by analyzing thirteen instructor interviews. Factors were further classified as internal or external; as related to factors of community, sources, curriculum, procedures, empowerment and feelings; and as institutional, networking or change management. Additionally, different levels of resistance or support were identified for each factor. Some results of our analyses include finding that supportive faculty chairs and colleagues strongly facilitate attempts at instructional change while departments open to change serve as a moderately supportive external factor towards instructional change. Student resistance constitutes the most frequent constraining factor that instructors face.

Keywords: Abstract Algebra, Instructional Approach, Change Strategy, Resistance, and Support.

Despite active learning emerging as an alternative pedagogical model, lecturing remains the predominant instructional model in science, technology, engineering, and mathematics (STEM) education (Freeman et al., 2014). According to Terenzini and Pascarella (1994), such preference toward lecturing may be due to the myth in undergraduate education that traditional methods of instruction provide effective means to teach undergraduate students. Lecturing focuses professors' actions and role towards covering content instead of student learning (Barr and Tagg, 1995). Active learning by contrast "engages students to do meaningful learning activities and think about what they are doing" (Prince, 2004, p. 223). While there are a variety of interpretations of *active learning*, a core element is student engagement in learning (Prince, 2004; Roehl, Reddy, & Shannon, 2013). Rasmussen and Wawro (2017) describe Inquiryoriented instruction (IOI), a particular form of active learning, as the kind of instruction in which students are engaged in doing mathematics and collaborating with peers. In inquiry-oriented instruction, instructors listen to students' ideas and use student thinking to advance the mathematical agenda. Rasmussen and Wawro report that this kind of instruction is beneficial for learners because it improves student success and promotes deeper learning and drawing connections between mathematics and real-world contexts.

Research outcomes have showed that active learning produces better student outcomes (Freeman et al., 2014; Rasmussen, & Wawro, 2017; Smith, Vinson, Smith, Lewin, & Stetzer, 2014). Freeman et al. (2014) analyzed scores of equivalent examinations, other assessments, and failure rates and found higher student performance for those in active learning rather than lecture classes. Authors like Terenzini and Pascarella (1994) and Prince (2004) both hold that active learning produces important gains in students' academic skills (such as thinking and writing) because non-lecture approaches provide more opportunities for students to explore and develop ideas for themselves.

Johnson, Keller, and Fukawa-Connelly (2017) identified that most abstract algebra (AA) instructors self-identify as lecturers and exhibit strong differences in pedagogical practices from non-lecture instructors. Thus, despite the benefits associated with non-lecturing models for instruction, lecturing continues to be the preferred instructional model in the teaching of AA. Additionally, despite the existence of different ways of changing the practice such as Action

Research¹ or professional development programs, change in undergraduate mathematics teaching has been minimal and strategies for change have been marginally incorporated (Henderson, Beach, & Finkelstein, 2011; Henderson & Dancy, 2007; Kezar, 2013). An important issue that arises then is identifying what factors may aid AA instructors in changing their teaching practice and what factors may constrain instructional change.

Our research question is: What are the constraining or facilitating factors that AA instructors face in their attempts at implementing new instructional approaches? The purpose of this study was to identify facilitating and constraining factors AA instructors face when they change their instructional practice toward inquiry-oriented instruction. These elements will provide benchmarks that can be considered in instructional change initiatives by the RUME community. Doing so will also provide useful considerations for individual instructors and researchers interested in facilitating local changes to instructional approaches.

Literature Review

Past literature has highlighted the importance of identifying and considering institutional and structural barriers and rewards (Henderson et al., 2011). Johnson, Keller, and Fukawa-Connelly (2017) found instructors' beliefs and institutional context were influential in understanding pedagogical decision-making and instructional change.

Facilitating Factors

By promoting change through developing reflective teachers, Henderson et al. (2011) found that change agents facilitate and encourage teachers towards change while defining change outcomes as well; "the change agent role is to use specialized knowledge to develop new environmental features that require or encourage new behaviors or attitudes that will lead to changes in instruction" (p. 962). Furthermore, reflection and peer support from their learning community helped faculty make improvements in their teaching. Henderson et al. (2011) found that successful change strategies consist of "coordinated and focused efforts lasting over an extended period of time" (p. 972), performance evaluations and feedback, and an intentional focus on changing faculty conceptions. Concerning the first aspect, holding workshops or short development programs are successful change strategies when the intention is focused on specific changes like the incorporation of new technology. With respect to the second aspect, Henderson et al. (2011) identified that one facilitator is providing feedback on teachers' practices. One of the forms of such feedback is through Action Research, whereby faculty take an active part in the study of their own classes. With respect to the third aspect, an intentional focus on changing faculty conceptions aligns with the idea that "meaningful educational change requires changes in beliefs" (p. 973).

Henderson et al. (2011) identified that developing reflective teachers as a strategy of change required certain support structures, such as dedicated faculty focused on instructional change to centers of teaching excellence. The most common facilitating factors were individual consultants and working groups.

Obstacles

Many reported obstacles come from K-12 education (Henderson et al., 2011; Johnson et al., 2017). Henderson et al. (2011) found that disciplinary affiliation, loose coupling, and reward

¹ Action Research (AR) is one strong tendency to change educational practice through research done by the same practitioner.

structures are features that affect the effectiveness of change strategies in undergraduate education. Johnson, Keller, and Fukawa-Connelly (2017) found that instructors report many constraints like time, content pressure, lack of curricular sources, knowledge, and departmental affordances. However, these authors report that instructors receive support from their departments for redesigning their course and for considering professional development opportunities. This highlights that departmental affordances seem to be a perceived resistant factor.

Following Henderson and Dancy (2007), situational factors are obstacles that prevent the use of alternative ways of teaching. In the teaching of physics, Henderson and Dancy (2007) identified the following obstacles to introducing research-based instruction in physics classrooms:

- Students' attitudes toward school: This refers to a lack of students' responsibility and their poor study skills.
- Expectations of content coverage: Teachers will not invest in research-based instruction if they must cover a lot of material. This constraint is also identified by Johnson, Keller, and Fukawa-Connelly (2017) in AA instructors.
- Lack of instructor time: Research responsibilities and teaching loads occupy instructors' time and thus lead instructors to avoid learning new instructional techniques.
- Departmental norms: It is difficult to implement a new instructional method if no other faculty are implementing it and there are no local role models who can help introduce this new instructional method.
- Student resistance: Some students do not like to interact with each other, and sometimes they are not prepared to think by themselves.
- Class size and room layout: It is hard to develop cooperative learning and formative assessments with large numbers of students.
- Time structure: One semester courses are not as conducive as year-long courses for identifying individual differences in learning needs.

In addition to these findings from undergraduate physics education, some constraints have been identified specifically with respect to implementing Action Research as an approach for changing instructional practice. In action research, the teacher is considered the best candidate for researching and changing his/her practice because he/she is the person who directly faces the problems studied. Gibbs et al. (2017) identified time management as one hindrance because research is regarded as a time-consuming activity, perhaps even more so when one is doing it oneself on top of teaching. Another barrier is resistance to change (Gibbs et al., 2017; Males, Otten, & Herbel-Eisenmann, 2010). In particular, Bianchini, Maxwell, and Dovey (2014) explicitly cite a variety of initiatives in Australia that proposed continuous reflection by academic staff. Such projects failed due to how ingrained the established system (which prioritizes commercial aims for higher education) was. According to these authors, universities had to sacrifice quality due to increasing political and economic pressures.

Even without the research component of action research, Henderson, Beach, and Finkelstein (2011) identify barriers in developing reflective teachers as a way to instigate instructional change; challenges arose when reform efforts did not align with institutional structures and pre-existing faculty beliefs. Other obstacles to individual change included the lack of recognition and rewards for improved instruction, lack of support, and lack of time. Lack of time was paralleled in Johnson, Keller, and Fukawa-Connelly's (2017) study of AA instructors who argued that their

main reasons for lecturing was a lack of time to redesign the class in addition to covering content.

As can be noted above, there is more literature on constraining elements than supportive ones. In our research, we attempted to identify supportive factors along with constraining factors to instructional change.

Framework

Following Henderson, et al. (2011), instructional change can be understood as "alterations in classroom practices" (p. 953) done by the instructor. Thus, we take *supportive factors* of instructional change to mean any factors that stimulate, provide for, promote or facilitate becoming different a classroom practice. Similarly, *constraining factors* are factors that limit or delay the process of doing a different practice. Additionally, Gibbs et al. (2017) argue that barriers for staff development can be constructed internally as well as externally. We assume that constraining and supportive factors can be classified as internal or external. *Internal* factors are within the control of the instructor who attempts instructional change. *External* factors are outside of the instructor's control.

We also consider the categorization that Hampton and Cruz (2017) propose regarding different factors that influence instructional change in undergraduate STEM education. We considered the following categories: *Change management* related to "the design and management of the change process itself" (Hampton & Cruz, 2017, para, 10); *institutional support* related to "the formal institutional support to the change initiative (Hampton & Cruz, 2017, para, 11); and *networking* regarding the relations with other members from the community, specifically relations with mathematics education community members. These authors also describe the category of *empowerment* as part of another category labeled as *faculty motivation*, the latter of which is defined as "factors related to the faculty's willingness to adopt RBIS [Research-based instructional strategies] in their classes." (para, 13) We adopt the category of empowerment, which refers the evocation of autonomy or change in students' participation in their learning process.

Methods

We analyzed 13 pre-existing interviews from AA instructors participating in the TIMES Project (Teaching Inquiry-oriented Mathematics: Establishing Supports). This study is focused on the following subset of interview questions:

- 1. Is your department chair supportive of efforts to try new instructional approaches? In what ways is s/he (un) supportive?
- 2. Are others in your department supportive of efforts to try new instructional approaches? In what ways are these colleagues supportive/unsupportive?
 - Have you had any experiences in which your colleagues were resistant to efforts you or others have made to teach in innovative ways? If so, can you give me an example of such an experience?
- 3. Have you experienced any student resistance to attempts you've made to teach in innovative ways? Can you give me an example?

We open coded transcripts for three interviews together, highlighting sections that we considered relevant without considering supportive or constraining categorizations. In the following step, each researcher coded five interviews individually, using the same criteria but with the addition of the same codes for expressions that paralleled those from the first coded interview when appropriate. With these 13 interviews coded, we reviewed the resulting codes

from each other's analysis, arriving at a total of 276 codes. We organized all codes recording interviewees' ID, the associated code and the portion highlighted from the transcripts corresponding to each code. In order to cut down on the number of codes, we then included all the codes in a sheet (S2) to identify which of them referred to the same principal idea. We organized codes referring to the same idea under new composite codes. This effort reduced the 276 codes to 19 codes. Then we created a final sheet (S3) which had three columns: the 19 codes, the different statements from the transcript that correspond to that code and the interviewer ID of the interviewee who expressed the statement.

We categorized the 19 factors as internal or external and included the frequency in which each code appears in the interviews. We also categorized the factors as *institutional, networking,* or *change management* depending on the nature of the factor. Because all instructors aimed to introduce inquiry-oriented instruction into their classes, we did not consider the category of faculty motivation. We also categorized the factors under the categories of *community, sources, curriculum, procedures, empowerment,* and *feelings* depending on the elements involved in the factor. For example, if the factor was associated with someone from the instructor's institutional context, then the factor was categorized in the community category.

Findings

The codes and the transcripts from S2 and S3 ground our analysis of the constraining and supportive factors we identified in the implementation of the new instructional approach. Frequencies of 23, 14 and 23 (Table 1) show that the majority of instructors' expressions refer to support from the chair, colleagues, and department respectively. In these cases, the chair and the department played an important role in affording instructors the opportunity to take a risk and try inquiry-oriented instruction in their classes. Additionally, the frequent constraining factor was student resistance, which appeared 25 times across the interviews (Table 1). In answering the third question, instructor J noted how some students "are like just very uh poignant about how I'm never taking an IBL course again" and instructor D mentioned student resistance because "my description for what I was going to do for the course, it didn't align with the course description in the catalog". These examples reveal student resistance lies in their lack of approaching toward depth situations that they must face in IBL as well as a break between the instructor's practice and students' expectations.

In table 1, we present 12 supportive factors and five constraining factors identified in S2. We also include the classification of each factor depending on their nature, the elements involved, and the corresponding classification according to the instructor's control:

	Frequen	Factor	Kind	Elements	Nature
	су				1 (00010
pportive factors	23	supportive faculty chair	External	Community	Institutional
	14	Supportive colleagues	External	Community	Institutional
		Department applies and			
		encourages a new instructional			
	23	approach	External	Curriculum	Institutional
		Previous elements that lead to	Internal-	Feelings-	
	20	change	External	Procedures	Institutional
Suj	9	Department open to change	External	Community	Institutional

Table 1. Supportive and constraining factors

		Department focuses on			
	4	teaching	External	Curriculum	Institutional
		Colleagues interested in			
		instructor's new instructional			
	8	approach	External	Community	Institutional
	8	Funding support	External	Resources	Institutional
		Benefits introducing the new		Empowerm	
	6	instructional approach	External	ent	Institutional
	8 positive teachers' feelings			Change	
		positive teachers' feelings	Internal	Feelings	management
		Connections with mathematics			
	6	educators researchers	External	Community	Networking
		Relations with mathematics			
	5	educators	External	Community	Networking
	11	not resistant colleagues	External	Community	Institutional
	2	No student's resistance	External	Community	Institutional
		Actions along the new			Change
	15	instructional approach	Internal	Procedures	management
	14	No interference	External	Community	Institutional
	4	Colleagues' resistance	External	Community	Institutional
nstraining factors	7 Negative teachers' feelings			Change	
		Internal	Feelings	management	
	12 Communication Problems			Change	
		External	Procedures	management	
		Situations introducing the new			Change
	18	instructional approach	External	Curriculum	management
Co	25	Students resistance	External	Community	Institutional

In the factor *Previous elements that lead to change*, some instructors mentioned their classes were previously lecture-oriented, and for various reasons, they realized a need for change. For instance, instructor I referred to the lack of student participation in the learning process:

Instructor I: I spent hours and hours and hours making up these detailed handouts and I was only talking to myself. I was having a little math party of one up at the front of the room and, [sic.] and nobody else was invited to that party. They were just watching.

Concerns over poor student learning outcomes and prior experiences with introducing some change (positive or negative), and existing relationships between department chairs and mathematics educators all positively impacted current attempts at instructional change.

Communication problems appeared as a frequent constraining factor. Some instructors also expressed problems due to misunderstanding the educational intentions or miscommunicating the methods of an inquiry approach. Due to instructors' autonomy in their instructional approach as well as for making decisions about researching, some instructors do not attempt instructional change because they do not perceive such research as valuable. The following excerpts are evidence of this finding:

Instructor E: We're not a, pretty much research is not part of anything. You don't have to do it if you don't want to.

Instructor F: No, I mean, its, its um, and there's not forced 'you have to do it this way'. This is, this gentleman is not going to be, you know, doing a bunch of inquiryin his classroom. It's not gonna happen. But as long as we don't make him, you know-As long as he gets to do things how he wants to do it, everybody's happy.

Conclusions

We identified supportive and constraining factors AA instructors faced when they sought to change inquiry-oriented instruction. The 13 IOI implementing instructors in this study met more supportive than constraining factors (12 supportive factors vs. 5 constraining factors). This differs from past literature focusing predominantly on constraining factors. We found that supportive faculty chairs, colleagues, and a department that enact and encourage a new instructional approach were three frequent external-institutional supportive factors that support the implementation of instructional change.

Henderson et al. (2011) establish that institutional support is not enough for instructional change; individual faculty must also be willing to engage in some kind of development. Our findings parallel those arguments. Specifically, we found two factors were pivotal towards achieving change: (1) a department that encourages instructors to introduce change and aids them in that process and (2) instructors' willingness to moving outside their comfort zones. The latter may come about when instructors realize that their lecture-based instruction has not produced the desired effect, resulting in a change of beliefs as well as a search for more effective forms of instruction.

Additionally, to implement a new instructional approach, instructors must recognize the need to clarify the intentions behind their instructional decisions and to change instructional methods in the first place. That will decrease students' resistance, which was the most frequent constraint identified in this study.

Our study found that the nature of most constraining factors is change management. It may be then that these constraints can be prevented if the instructor is aware of them from the beginning and can plan accordingly. Although colleague resistance is an external factor outside of an instructor's control, it is not a strong constraining factor and thus may not influence instructors' instructional change efforts substantially.

As a parting note, this study provides hope to those instructors contemplating change by showing that change is possible and different constraints regarding time and expectations may not be as severe as prior research may make it out to be. For researchers interested in promoting ways for instructional change, this study provides different constraints factors that can be handle previously as well as supportive factors that can be used for strengthening such proposals.

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