A Tale of Four Departments: Interdisciplinary Faculty Learning Communities Informing Mathematics Education

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Abstract

As a result of the Curriculum Foundations Project and the SUMMIT-P consortium, faculty from four different departments at Lee University created a Faculty Learning Community (FLC) with the goal of improving students' attitudes toward undergraduate mathematics courses, including students' perception of the utility of mathematics in their lives and the feelings of anxiety that they experience in these courses. The interdisciplinary collaborations resulted in introducing novel activities and manipulatives in various mathematics courses (Introduction to Statistics, Concepts of Mathematics I and II, and Algebra for Calculus). This paper first describes the efforts of creating the inter-departmental FLC. Second, it discusses the interventions that were introduced in the mathematics courses. Finally, it reflects on the lessons learned while participating in the learning community. The goal is to guide and challenge readers to consider how similar collaborative opportunities can be initiated at their own institutions.

Keywords

Faculty Learning Community, interdisciplinary, mathematics, education

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The Curriculum Foundations (CF) Project was part of an extensive review by the Mathematical Association of America of undergraduate programs in mathematics from 1999 to 2007 (see Ganter & Barker, 2004; Ganter & Haver, 2011). Specifically, the CF Project hosted workshops for 22 disciplines to assist mathematics faculty in gathering information about the mathematics concepts and skills that are important for students understand when pursuing majors in the partner disciplines. The findings from these workshops were summarized in Ganter and Barker (2004) to help guide changes to undergraduate mathematics instruction. One of the important conclusions was that, "Promoting and supporting informed interdepartmental discussions about the undergraduate curriculum might ultimately be the most important outcome of the Curriculum Foundations Project" (Ganter & Barker, 2004, p. 6).

Recommendations from the CF Project led to the creation of a National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Teaching Partnerships (SUMMIT-P), a large-scale project uniting numerous colleges and universities with the mission of creating Faculty Learning Communities (FLCs) consisting of mathematicians and faculty from other disciplines. These FLCs were tasked with discussing ways to implement the CF recommendations in targeted mathematics courses and, by extension, improve student learning.

In this paper, faculty at Lee University describe the process of creating and cultivating a FLC, and using the FLC to implement interventions in different mathematics courses. Challenges to maintaining a FLC, proposed solutions to these challenges, and the impact of the FLC on both faculty and students will also be discussed.

Defining and Creating a Faculty Learning Community

FLCs are "collaborative collegial groups of faculty and other teaching staff who are interested in and committed to the improvement of their teaching to accommodate a diverse student population through group discourse, reflection and goal setting" (Ward & Selvester, 2011, p. 2). FLCs may function to address the needs of a specific group of faculty or staff, or focus on improving teaching and learning through interdisciplinary collaboration (Cox, 2004; Nugent et al., 2008). These collaborations may improve teachers' confidence and understanding of how students learn (O'Meara, 2005). In addition, FLCs have positive benefits for student learning, including better class discussions, written work, and class atmosphere (Beach & Cox, 2009).

Given the mission of SUMMIT-P and results of the existing research on FLCs, faculty at Lee University sought to create a learning community to implement the CF recommendations in mathematics courses. Lee is a small, liberal arts institution in the southeastern United States comprising approximately 5,000 students. Most students are required to complete at least one mathematics course, such as Introduction to Statistics, as part of an undergraduate major, in a discipline such as biology, chemistry, political science, psychology, criminal justice, nursing, education, or mathematics.

Because students taking mathematics courses represent a breadth of disciplines, our FLC consists of faculty from four departments: Mathematical Sciences; Behavioral and Social Sciences; Natural Sciences; and Early Childhood, Elementary, and Special Education. A summary from each participating faculty member about how the FLC was formed and utilized to improve student learning is outlined below.

Caroline Maher-Boulis, Department of Mathematical Sciences

As the PI of the project, I initiated the collaboration between the co-PIs representing each of the departments by first consulting the CF Project's publication, *Voices of the Partner Disciplines*, (Ganter & Barker, 2004), for discipline-specific recommendations. We reviewed the recommendations for chemistry (Ganter & Barker, 2004) and for Teacher Preparation: K-12 Mathematics (Ganter & Barker, 2004). The Social Science recommendations came from the document developed through phase II of the CF Project (Ganter & Haver, 2011). We then selected five mathematics courses on which to focus our work: Introduction to Statistics (with Behavioral and Social Sciences as the partner discipline); Algebra for Calculus (with Natural Sciences as the partner discipline); and College Algebra, Concepts of Mathematics I, and Concepts of Mathematics II (with Education as the partner discipline). This initial step acquainted us with the concept of a FLC and provided preliminary information about the partner disciplines' mathematical needs.

Bryan Poole, Department of Behavioral and Social Sciences

My department is composed of students majoring in psychology, sociology, and anthropology. All students are required to pass Introduction to Statistics before they can register for the mathematics-focused courses in the major. Psychology majors take Introduction to Research Methods and Statistics. Sociology and anthropology majors take Research Methods and Statistics I. Together, these courses emphasize many of the concepts that are taught in Introduction to Statistics, such as descriptive statistics, properties of a normal distribution, and graphical representations of data, and provide students with opportunities to apply these concepts. Not surprisingly, many of our students have a difficult time transitioning from Introduction to Statistics into their major methods and statistics courses, primarily because they tend to forget some of the course content, are unable to connect content from one course to another, or experience anxiety related to studying the content.

One of my first tasks as a partner discipline representative was to consult the CF recommendations, which include a list of necessary, desirable, and optimal skills for the social sciences (Ganter & Haver, 2011). Reviewing these skills provided a springboard for conversations with my psychology and sociology colleagues, who shared through the FLC their recommendations about which of these skills should be emphasized. Our discussions produced a wish list containing eight skills that we wanted to be highlighted in Introduction to Statistics.

My next task was to align the contents of my department's wish list and the CF recommendations with the topics listed in the Introduction to Statistics syllabus. For example, correlation and regression in the syllabus correspond to the CF recommendations and wish list items of conceptual understanding; understanding graphical representation and interpretation; and grouping problems in a social science context. Mapping wish list items with course topics paved the way for additional discussions between members of the FLC and mathematics faculty about where various skills should fit into the Introduction to Statistics curriculum.

John Hearn, Department of Natural Sciences

Many science students dread the mathematical components of chemistry and biology. Chemistry, in particular, has many mathematical concepts and skills integrated throughout the curriculum. Students, therefore, must transfer their mathematical knowledge into the science classroom. Some problems require algebraic manipulation, other problems require graphical interpretation, and still other problems require simplification to understand the functional dependencies between variables. These and other mathematical knowledge and skills are prerequisites for many college-level science courses.

I began my involvement with the FLC by reviewing the CF recommendations for chemistry and biology (Ganter & Barker, 2004). Then I gathered input from both biology and chemistry faculty about which algebraic concepts and skills were most important in the classes they teach. We organized this input into a wish list of high priority concepts and skills that the science faculty at Lee believe are important prerequisites for their students. We then met with mathematics faculty to discuss the learning objectives for Algebra for Calculus to determine whether these concepts and skills are addressed. Overall, there was good overlap between the needs of the chemistry and biology faculty and the learning objectives in the algebra class. Every concept or skill aligned with a specific learning objective listed on the syllabus. One learning objective, while listed on the syllabus, was not historically covered in the algebra class—logarithms. Students taking General Chemistry II need a well-developed understanding of these functions and need to be proficient at algebraically rearranging equations with logarithms and exponents. The FLC discussed ways in which the algebra class could be revised to include a full treatment of logarithms.

Following this initial meeting, the collaboration was maintained in two ways. First, I worked with biology, chemistry, and mathematics faculty to develop activities that the algebra faculty could use in their classes. These activities help students explore the application of algebraic concepts and skills to chemical and biological problems. The activities begin by providing a short introduction of the chemical or biological topics followed by the algebraic problem needed to solve problems in these subject areas. Students then solve the algebra problem in by applying mathematics concepts ranging from algebraic manipulation to graphical interpretation.

Second, the chemistry faculty are engaged in ongoing discussions about how they can help bridge the gap between preparatory mathematics classes and chemistry classes. I made supplemental videos to demonstrate how to algebraically manipulate chemical equations, how to use calculators, and how to solve more advanced functions numerically. The chemistry faculty has also revised the general chemistry courses to help students succeed who often struggle with some of the mathematical concepts and skills needed to solve chemistry problems. The overall goal is to make a path for students to overcome challenging algebraic concepts and skills by providing the necessary scaffolding, tutoring, and practice.

Jason Robinson, Department of Early Childhood, Elementary, and Special Education

The Helen DeVos College of Education is composed of two departments: Early Childhood, Elementary, and Special Education (ECESE) and Health, Exercise Science, and Secondary Education (HESSE). ECESE students are required to take several mathematics courses including Concepts of Mathematics I, Concepts of Mathematics II, and College Algebra. HESSE students, depending on the major, could be required to take up to 16 hours of mathematics courses in addition to the general core curriculum. Many of our students, especially in the ECESE department, express high levels of mathematics anxiety and hesitation about taking mathematics courses and completing math-focused assessments. This anxiety has caused our students to postpone required courses until the last minute and has even resulted in delayed graduation for some due to not registering for classes or avoiding the tests required for Tennessee teacher certification.

As a partner discipline representative, my first task was to examine the CF *Voices of the Partner Disciplines* publication (Ganter & Barker, 2004) which includes a list of five principles to guide the preparation of teachers, specifically in mathematics. During an ECESE departmental meeting, faculty discussed these principles in detail and selected two to be the focus of our mathematics courses for preservice teachers (Concepts of Mathematics I & II and an elementary teaching methods course). Our wish list was comprised of these two principles.

I spoke extensively with mathematics faculty who were teaching courses for College of Education students. Those discussions and collaborations provided rich opportunities to learn from one another and gain insight into various pedagogical practices that were currently being employed in both education and mathematics classes. In addition to the enlightening discussions, faculty also visited each other's classrooms to observe and document teaching practices. After quickly discovering that students' mathematics anxiety was high, we determined to do everything possible to decrease their anxiety and help them feel more comfortable in and prepared for their mathematics courses. That is, it was clear that the two items on our wish list extremely relevant and applicable. The principles we focused on are:

1. Tools for teaching and learning, such as calculators, computers, and physical objects, including manipulatives commonly found in schools, should be available for problem solving in mathematics courses taken by prospective teachers.
2. Mathematics courses for future teachers should provide opportunities for students to learn mathematics using a variety of instructional methods, including many we would like them to use in their teaching.

Expanding the Faculty Learning Community

The FLC hosted additional meetings to facilitate the collaboration between mathematics and partner discipline faculty. For example, a fishbowl activity took place in which faculty from the collaborating departments discussed the mathematical needs of their disciplines, while the mathematics faculty listened and took notes. Meetings with faculty from individual departments were scheduled to further support the collaboration, discuss ideas for interventions, and learn more about the topics and skills included on the wish lists of the partner disciplines.

Caroline Maher-Boulis, Department of Mathematical Sciences

As the instructor for Algebra for Calculus, I listened to the discussions of faculty from the chemistry, biology, and health science disciplines during the fishbowl activity. The activity allowed me to learn about and better understand the needs of the disciplines that require students to take Algebra for Calculus. The discussions revealed that partner discipline faculty assumed some algebra topics were being addressed in the course while in fact they were not. This was a significant revelation to both parties that illustrated the need for more class time to cover these topics many of which were addressed toward the end of the course. Consequently, faculty proposed the course to be redesigned as a four-credit-hour course instead of a three-credit-hour course. Moreover, faculty from the health science division provided ideas for application problems to be created for use in the course.

Individual meetings with some other departments were not as effective. Although they shed light on why the departments require students to take the course, the meetings did not result in the development of specific applications that could be effectively used in the course.

Amanda Jones, Department of Mathematical Sciences

During the initial meetings, I was teaching only one of the courses highlighted in this project, Introduction to Statistics. By attending the fishbowl activity, I was able to learn from my colleagues in the social sciences. I was also presented with the wish list and the map of how different the items aligned with topics in the course syllabus. I listened as my colleagues talked through challenges with trying to teach concepts in their disciplines that built on material that was covered in my course. As we continued to have more fishbowl meetings, I learned more about which topics were important to other departments across campus, such as the School of Business, the HESSE department, and others. One theme that was consistent across each discipline was the desire to have incoming students be more proficient in working with Excel. This inspired me to add activities to my course that required students to use this program. I also made supplemental videos that introduced basic concepts to students who were unfamiliar with Excel. Another outcome from these meetings was problem sets developed by Bryan Poole that incorporate social science contexts for use in the statistics course.

While I was not involved in the initial meetings with the College of Education faculty, I began teaching Concepts of Mathematics I a year later. When this course was assigned to me, I attended a similar fishbowl where I heard from College of Education faculty about their needs for this course. Specifically, faculty indicated that students enrolled in the course would benefit from the use of mathematical manipulatives to help the students develop a deeper understanding of the content. Future teachers also benefit from using manipulatives as they need learn how to use them in the classroom.

Patricia McClung, Department of Early Childhood, Elementary, and Special Education

As Chair of the ECESE department, it has been a pleasure to watch the ongoing collaboration that has taken place between the Helen DeVos College of Education and various partner disciplines. On the university campus, collaborations like this are not always the norm.

The initial fishbowl activity was extremely important for several reasons. First, it provided an opportunity for the SUMMIT-P team to inform key leaders about the project and to cast a vision for this project on our campus. Second, the activity provided rich conversation and collaboration among faculty members and university administration. Third, it provided partner disciplines with an opportunity to not only share strengths, but also areas of need in our content areas. And lastly, the fishbowl activity gave participants an opportunity to recognize overlapping content present in our programs and discuss ways to use those similarities for the betterment of our students.

Once the fishbowl activity was completed, Jason Robinson began to communicate directly with education and mathematics faculty members about the wish list and how the needs of partner disciplines could be addressed. Additional fishbowl activities took place, classroom observations were scheduled, and the FLC was quickly providing the necessary support and guidance for changes in our classes.

The impact of this team did not only involve faculty from education, mathematics, and social sciences. The SUMMIT-P team also felt it was important to introduce their work to faculty members across campus. They provided several sessions in the Center for Teaching Excellence and also collaborated further with faculty members in other ways.

Introducing Changes to Mathematics Courses

The next step for the FLC was utilizing the information gathered from meetings with other faculty, the partner discipline wish lists and syllabus maps, to implement the CF recommendations in the targeted mathematics courses. Specifically, various interventions that were designed to improve students' understanding of and attitudes toward mathematics were selected and developed. What follows is a discussion of how these interventions were chosen and used in the mathematics classroom.

John Hearn, Department of Natural Sciences

The chemistry and biology faculty recommended one course change and provided a series of activities to be resources for the classroom or used as supplements to homework assignments. First, we recommended that the Algebra for Calculus course be revised to include a thorough focus on logarithms. To accommodate this change, we examined the course topics and recognized that equations with one unknown can be treated as a special case of equations with two variables. We recommended that less time be devoted to equations with one unknown to allow for time later in the semester for introducing logarithms.

Second, we provided a series of activities as resources for algebra faculty to use. These activities, which focus on a variety of algebraic skills and competencies, show the application of algebra in health science (medicine dosage), biology (population dynamics), and chemistry (Haber process and equilibrium concentrations). The activities include graphically analyzing data, graphically solving complex polynomial equations, algebraically manipulating equations, and rearranging and interpreting equations with variables other than x and y. All of these skills align with the CF recommendations (Ganter & Barker, 2004). Each activity includes a discipline-specific introduction. In some activities, a worked example is provided so that students can see the application of the algebraic concepts and skills to the types of problems being featured. This type of direct instruction is argued to be the most efficient method of learning for most students (Clark et al., 2012; Rosenshine, 2012).

Caroline Maher-Boulis, Department of Mathematical Sciences

Of the interventions mentioned above for the Algebra for Calculus course, the activities with applications to health science and biology were used in the class. These applications cover the concepts of linear equations in two variables, functions, graphs and their interpretations. The students practice manipulating equations algebraically, rearranging and interpreting them and analyzing data.

I try to introduce these interventions at the appropriate time according to the level of difficulty as well as the concepts and skills covered in the course. I typically start with the interventions that feature functions, as they give the students an introduction to the concept and solidify the terminology used (e.g., independent and dependent variables, domain and range) throughout the course while providing a simple application to the mathematical concept. As students learn more about different types of functions, I assign the intervention on population dynamics which involves the simplest of functions, linear functions. In this intervention students are given a table of values showing population changes in light and dark moths over nine years. Students are asked to plot the data points and find lines of best fit. They are then asked to calculate slopes, find intercepts, and write equations representing each linear function, and to interpret these quantities as well as the information presented in graphs.

Throughout the course, students are exposed to the concept of functions in various ways (i.e., verbally, graphically, algebraically, and numerically) and become more comfortable working with functions. It is at this stage that I assign the health science application on medicine dosage, which helps students realize that graphs of functions need not be continuous and may not be in any of the familiar forms covered in class (e.g., polynomials, exponential functions, logarithmic functions). The last intervention I use is a population growth problem, which introduces students to the future calculus concept, rates of change.

I have not been able to use the chemistry interventions to date, as they were too technical for the students. It is our intention to continue working on these interventions to make them more accessible to the level of students in the Algebra for Calculus class.

Bryan Poole, Department of Behavioral and Social Sciences

To address the items on my department's wish list, I recommended three types of interventions to be used in Introduction to Statistics. First, to help students see how various statistical concepts (e.g., the normal distribution, central tendency, data visualization) can be applied in other disciplines, I provided mathematics faculty with a list of problems relevant to social science majors. For example, in one problem students are presented with a table of data and are asked to decide which of four bar graphs best represents the raw data. Instructors are encouraged to assign these items as in-class activities or as part of a homework assignment.

After the mathematics faculty provided feedback about these problems, I converted many of the questions into prompts for group discussions or debates to increase the likelihood of faculty utilizing them and students engaging with them. For example, one prompt requires two teams of students to debate whether it is appropriate to compare the mean age for marriage in Canada and the median age for marriage in the United States. I also retained the format of some individual questions focused on social science content in case instructors wanted to use them in other ways.

Second, I recommended the use of manipulatives called Poker Chip People (Sledjeski, 2016), a resource designed to help students simulate sampling from a diverse population and to facilitate statistical analyses with realistic data. Instructors present students with a bag containing 100 poker chips that represent 100 people, each of which is covered by a colored label containing information about that person (e.g., gender, happiness level, and income). After students draw chips from the bag, they are instructed to practice various statistical analyses (e.g., descriptive statistics, probabilities, linear regression) that are outlined in the accompanying resource manual.

After purchasing enough poker chips, labels, and bags to accommodate multiple instructors, I met with the mathematics faculty to introduce the manipulatives. Each instructor received their own bag of chips and a resource manual. They submitted questions and provided feedback about the manipulatives before using them in Introduction to Statistics. In addition, I also helped create a spreadsheet to simulate the use of these manipulatives in the event that faculty are unable to use them or do not wish to use the actual poker chips in their classroom (e.g., for hygiene purposes). After years of use, mathematics faculty have suggested that these manipulatives have improved their students' enjoyment and understanding of statistics.

Finally, I helped organize the Student Exchange Program (SEP), a student learning community designed to facilitate opportunities for interdisciplinary collaboration between students majoring in mathematics and social sciences (Poole et al., 2020). Students in the SEP work together to complete various activities designed to improve their conceptual understanding and perceived utility of statistics. Some of their activities, such as generating problems, leading recitation sections, developing novel manipulatives, and tutoring, have also aided students enrolled in Introduction to Statistics.

Amanda Jones, Department of Mathematical Sciences

Broadly, I found the recommendations and interventions helpful in both the Introduction to Statistics course and the Concepts of Mathematics I course. For example, I used the list of problems provided by Bryan Poole in many ways. I inserted them into problem sets, incorporated them into class discussions, and even used the questions on exams. I consistently use the Poker Chip People activity to demonstrate different sampling methods. I found both of these interventions useful not only for the social science majors in my courses, but for most of my other students, as well.

In addition to being an instructor of Introduction to Statistics, I am also the director of the Mathematics Tutoring Lab, which is primarily visited by students enrolled in the statistics course. I have found that one of the best outcomes of the statistics part of this project is the development of the Student Exchange Program, which has provided staff for the tutoring lab, ensured statistics students could get additional help outside of class, and created valuable conversations between mathematics and social science majors as they have tutored statistics students.

Jason Robinson, Department of Early Childhood, Elementary, and Special Education

The department's wish list provided the framework needed to make changes to our mathematics courses for preservice teachers. With the CF document as our guide, interventions were made in Concepts of Mathematics I and II and in an elementary methods of teaching course.

The first intervention introduced was the addition of manipulatives in mathematics instruction, such as fraction towers and Base 10 blocks. After visiting Concepts of Mathematics I and II, I immediately recognized a need for incorporating manipulative use in instruction. Students were frustrated and anxious because of their lack of understanding about course content. According to Stein and Bovalino (2001), manipulatives are very important tools that can help students think and reason in meaningful ways. Sutton and Krueger (2002) found that with the use of manipulatives, students' mathematical interest was increased. In the elementary and middle school classrooms, where many of our students find careers, manipulatives are not only used, but are expected to be incorporated in mathematics lessons. For these reasons, manipulative use was recommended as an intervention in our classes for preservice teachers.

The methods by which a teacher introduces manipulatives plays a significant role in how well the concepts transfer to students. For this reason, it is very important that teachers understand how to appropriately use manipulatives during the instructional time (Robinson et al., 2020). Professional development training on the use of manipulatives in the classroom was conducted by a mathematics specialist from the local school district for education and mathematics faculty. These training sessions offered a unique opportunity for faculty members to learn about new manipulatives being used in classrooms, in addition to current pedagogical practices.

Another intervention that was recommended was a restructuring of the mathematics manipulatives exam taken by students who complete a course in elementary teaching methods. After a close review of the exam, we found that manipulative use in the course was minimal, and the tools used were often outdated and no longer relevant for the classroom. For that reason, I had extensive conversations with public school teachers about the current use of manipulatives in K-8 classrooms and the various pedagogical practices that were employed when teaching mathematics to elementary and middle school students. I shared my findings with the instructor who focuses on mathematics instruction in the elementary teaching methods course. This eventually led to us purchasing additional mathematics manipulatives and beginning the work of restructuring the outdated mathematics manipulatives exam. This work is ongoing and will continue so that we can ensure that our practices and methods are relevant for students preparing to teach in public-school classrooms.

Amanda Jones, Department of Mathematical Sciences

For Concepts of Mathematics I and II, I have been provided with class sets of valuable manipulatives, such as Base 10 blocks, snap cubes, Cuisenaire rods, and fraction towers to use. I regularly use these manipulatives to demonstrate concepts and have students practice teaching each other with these materials. Robinson et al. (2020) provides more details on how these manipulatives are used effectively in the classroom. This project has also funded two different workshops with a mathematics specialist to reinforce and enhance how to use these manipulatives in instruction.

Patricia McClung, Department of Early Childhood, Elementary, and Special Education

At the end of the first semester of the senior year (Clinical Semester I), elementary education majors complete a mathematics manipulative exam to assess their ability to conceptualize various mathematics concepts and to teach them to children in PK-5 classrooms. In addition to understanding the concepts, each candidate also demonstrates their ability to teach mathematics concepts in a variety of PK-5 settings.

Manipulative use in Concepts of Mathematics I and II for elementary majors has also been an intervention that has been vital to the success of our students. A required mathematics task assessment is another area where we have seen growth, not only in student confidence level but also in overall achievement. After ideas were shared and strategies were gathered from the collaboration between the Department of Mathematical Sciences and the College of Education, an improvement was noted in the teacher candidates' abilities to both solve mathematical tasks and teach them. The scores for the mathematics task assessment increased and there was a noticeable difference in the affective stance of the candidates. They portrayed more confidence and conviction concerning their preparation for and performance on this particular assessment.

Professors who supervise student teachers have seen a direct correlation between the increased use of manipulatives in the relevant courses taught in the College of Education and the Department of Mathematical Sciences and in the performance-based assessment that is required of all teacher candidates. Additionally, candidates reported greater ease in the student teaching setting. It has been noted that PK-5 students were more engaged, and they made meaningful connections between real world situations and mathematics. Students in the classroom were also physically involved in the learning process and were able to visualize different scenarios and outcomes.

Another unexpected outcome of the interventions revolved around the ability to translate the effects of using manipulatives into the virtual world during the time of the COVID-19 pandemic. Many of the student teachers were required to teach virtually and were at ease teaching with virtual manipulatives in the online mathematics classroom. This was an added benefit for teacher candidates and for student engagement overall.

Lessons Learned

Several challenges were encountered while sustaining the FLC. The first challenge faced, and perhaps the most prevailing one, is receiving faculty buy-in for initiatives like the one undertaken at Lee University. The interdisciplinary collaborations worked well in the Algebra for Calculus and Concepts of Mathematics I and II but not so well in College Algebra and Introduction to Statistics. Faculty members of the former classes saw the real benefit of these collaborations and were open to learning new techniques and listening to the needs of the partner disciplines. Conversely, very few faculty members in the latter courses saw the benefits or were open to sharing and communicating their knowledge and sharing their experiences.

Another challenge for faculty involvement in revising a first-year mathematics class, such as Algebra for Calculus, is that many science students begin their college-level mathematics at a level higher than algebra. Those students will not receive any benefit of curricular or pedagogical revisions to the Algebra for Calculus class, because they will never take the class. This diminished return on investment tends to shift the faculty focus to other endeavors.

A more general challenge facing our FLC is measuring its effect on student learning. So far, efforts to quantify the effects on student performance in general chemistry has yielded no statistically significant difference between students who have taken the Algebra for Calculus class, for instance, and students who tested out of algebra. A broader and more lasting impact to faculty would naturally follow when student learning measurably improves.

Despite these challenges, several successes were also experienced throughout the FLC. For example, participating in the FLC has afforded faculty the opportunity to exit their discipline-specific silos, learn more about the needs of other departments, and enjoy the camaraderie afforded by frequent communication (Bishop et al., 2020). The common goal of improving student learning has been a catalyst for unification and successful discussions during the last five years.

In addition, the FLC has established a collaborative network that affords ongoing, sustainable partnerships between mathematics and partner discipline faculty that may last beyond the lifespan of SUMMIT-P. Even now, as the FLC extends into its sixth year, faculty are actively seeking ways to improve students' ability to transfer knowledge from mathematics courses into partner discipline courses. For example, social science and mathematics faculty are currently working together to test new interventions that help students solve statistics problems by comparing and contrasting multiple problem-solving strategies (see Rittle-Johnson et al., 2020). Chemistry faculty are seeking to develop a required "mathematics for chemistry" class for all first-year students to cover a variety of topics (graphical analysis, how to use a calculator, spreadsheet analysis, etc.), as well as the computational skills students need to be successful for college level chemistry. Furthermore, chemistry faculty are discussing a remedial co-requisite course for students who test out of algebra but are not proficient on prerequisite algebraic concepts. This remediation, which has been effective at Texas Tech University (Hesser & Gregory, 2016), would be required for all students who do not meet the prerequisite knowledge standards. Taken together, these efforts at revising the curricula will benefit from continued collaboration with mathematics faculty.

Conclusion

FLCs provide a host of benefits and challenges for participating faculty and staff. For example, they can serve as the catalyst for interdisciplinary collaboration, break down discipline-specific silos in academia, and increase camaraderie among participants. More importantly, FLCs can provide novel opportunities to improve student learning. By sharing the details about the FLC formation and activities, the goal has been to guide and challenge readers to consider whether similar collaborative opportunities can be initiated at their own institutions.

Sidebar

As mentioned at the beginning of this paper, SUMMIT-P is a multi-institutional project in which all participating institutions created their own FLCs. What follows is a description of how similar FLCs, from four departments, were formed at Ferris State University. This sidebar also discusses the challenges faced at that institution, some of which are similar to challenges faced at Lee University.

FLCs at Ferris State University

As co-PIs of the Summit-P project at Ferris State University, we initiated the idea of facilitating a FLC by bringing together faculty from a variety of disciplines. One of our main goals of the FLC was to create a plan to teach mathematics and quantitative reasoning concepts across disciplines in an attempt to reduce student mathematics anxiety. Members of the SUMMIT-P team at Ferris reached out to faculty in social work, nursing, business, and mathematics, which ultimately led to the creation of four interdisciplinary teams that all met together every three weeks. These teams consisted of one faculty from mathematics and one from each of the other three disciplines. While the pedagogical strategy (a case scenario involving Hurricane Katrina) developed and implemented into identified courses in each of the four disciplines was generally successful, it was not without its challenges. Among the challenges we faced were (1) having faculty join the FLC primarily for the stipend associated with it; (2) developing an assessment plan to measure changes in student mathematics anxiety; (3) unexpectedly having to spend time learning the "languages" of the four disciplines; and (4) working with non-mathematics faculty who were not skilled in teaching mathematics concepts in their discipline.

Because our FLC was supported by our Faculty Center for Teaching and Learning, all participating faculty were provided with a $1200 stipend for completing the year-long commitment. Getting any group of faculty members together every three weeks over the course of a year is difficult, and the FLC proved to be no exception. The attendance and amount of work put forth varied among FLC participants. Though all participants actively participated in creating a set of community norms at the beginning of the FLC, not everyone was equally committed to them. This left their team members to do more work than they initially anticipated, and made it difficult to establish cohesion among members of the whole group. In the future, it would be well worth the effort to interview the people who volunteer to participate to better understand their motivation and expectations for participating.

A second challenge was the development of an assessment plan to examine outcomes associated with the implementation of the case scenario. While an assessment plan was discussed by the SUMMIT-P team at Ferris, there was little time between the decision to host a FLC and the start of the FLC. In most circumstances, an assessment plan is developed at the beginning of a project such as this and helps guide the development and implementation of the intervention. In our case, several cohorts of students have now been exposed to the intervention and an assessment plan is still not in place. While there are anecdotal accounts from faculty as well as assignment and course grades, we do not have specifically linked assessment measures of mathematics anxiety in place. This impairs our ability to conclude that the interventions we designed and implemented work to reduce mathematics anxiety.

A third challenge we experienced was underestimating the time and effort it would take for team members to learn the languages of the other team members. Even basic terms like "variable" were used differently in each of the disciplines. Without a mutual understanding of how the mathematics concepts were used in the various disciplines, it was sometimes difficult for team members to communicate as to how best to implement the case scenario in mathematics courses and in the respective disciplines.

The fourth challenge we faced was that faculty from social work, nursing, and business had not themselves taken a mathematics course in many years, and felt unprepared to teach mathematics concepts in their non-mathematics courses. This necessitated that the mathematics faculty "re-educate" the faculty in other disciplines on basic mathematics concepts like proportions, linear functions, and exponentials, and assist them in developing applications in their specific disciplines. Although this was challenging for all faculty, one of the benefits of the challenge was that non-mathematics faculty now better understand those basic concepts, and mathematics faculty gained experience in teaching the concepts to the FLC participants, who like their own students, had almost completely forgotten them.

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