Structured Engagement for a Multi-Institutional Collaborative to Tackle Challenges and Share Best Practices

Rosalyn Hobson Hargraves
Virginia Commonwealth University
rhobson@vcu.edu

Stella K. Hofrenning
Augsburg University
hofrenni@augsburg.edu

Janet Bowers
San Diego State University
jbowers@sdsu.edu

Mary D.R. Beisiegel
Oregon State University
beisiegm@oregonstate.edu

Victor Piercey
Ferris State University
victorpiercey@ferris.edu

Erica Slate Young
Appalachian State University
slateer@appstate.edu

https://doi.org/10.25891/vf7a-ps53

Abstract

A National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships (SUMMIT-P), funded by the National Science Foundation, is a multi-institutional consortium with members from twelve institutions. The consortium adapted two protocols developed by the School Reform Initiative to: 1. provide advice on challenges or dilemmas a consortium member is facing and 2. share project successes with consortium members. The two protocols—a Modified Descriptive Consultancy protocol and a Modified Success Analysis with Reflective Questions protocol—provide a structured format for these discussions. This paper provides an in-depth description of the two protocols and how they have been used for this project. Examples demonstrating the impact of the protocols are provided by the co-authors.

Keywords

collaboration, continuous improvement, interdisciplinary, protocols,

The success of interdisciplinary, multi-institutional collaborations hinges upon how well the partner institutions engage with and support each other. The National Science Foundation often funds projects which feature multiple institutions. One such grant is the National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships or the SUMMIT-P project (National Science Foundation, 2019, SUMMIT-P, 2019). SUMMIT-P was established to refresh lower division undergraduate mathematics curriculum (e.g. college algebra, pre-calculus, calculus, differential equations, etc.) based upon the expressed needs of other disciplines which require mathematics as part of their curriculum, i.e., the partner disciplines (e.g. biology, business, chemistry, economics, engineering, nursing, physics, social work, etc.). SUMMIT-P was built upon the work of the Curriculum Foundations (CF) project (Ganter & Barker, 2004; Ganter & Haver, 2011) which gathered input from partner disciplines on the mathematics topics students needed to master to be successful in their respective field of study. The CF project resulted in 22 reports, which the SUMMIT-P project used as a springboard for implementing the CF recommendations across 12 institutions and a variety of disciplines.

A project that originally included ten institutions, the SUMMIT-P Consortium now includes Augsburg University, Embry-Riddle Aeronautical University, Ferris State University, Humboldt State University, LaGuardia Community College, Lee University, Norfolk State University, Oregon State University, Saint Louis University, San Diego State University, University of Tennessee Knoxville, and Virginia Commonwealth University. The consortium has more than 50 team members across approximately 20 disciplines and from 15 institutions. These include the aforementioned institutional members in addition to the evaluation team member institutions: Appalachian State University, Duke University, and Virginia Polytechnic Institute and State University. With such a large group of participants geographically located across the United States, it is necessary to establish an effective means of sharing successful practices and facilitating peer learning. Drawing on the experience of some consortium members in K-12 education, the project management team identified two protocols which provide a format for effective and fruitful discussion during the principal investigator (PI) meetings, which occur over the internet once a semester, and the annual project meetings, which occur in person at the Joint Mathematics Meetings. The two protocols, the Descriptive Consultancy protocol and the Success Analysis with Reflective Questions protocol, were chosen because of documented effectiveness in educational settings (Yau & Lawrence, 2020; Mindlich & Lieberman, 2012; Bryk, 2010) and the experience of selected team members in the use of the protocols. The protocols were modified slightly to tailor them to the needs of the SUMMIT-P project.

The two revised protocols—a Modified Descriptive Consultancy protocol and a Modified Success Analysis with Reflective Questions protocol—provide the SUMMIT-P project a structured format for (a) feedback to partners who are seeking advice on a challenge they are experiencing and (b) partners to share their success stories.

Each of the activities adhere to a schedule to prevent discussions from spiraling off topic and to respect the participants' time. This paper provides an in-depth description of the two protocols and how they have been used for this project. Examples from co-authors Janet Bowers from San Diego State University, Mary Beisiegel from Oregon State University, Victor Piercey from Ferris State University, Stella Hofrenning from Augsburg University, and Erica Slate Young from Appalachian State University are also shared.

Overview of the Protocols

Developed by the School Reform Initiative (SRI) (McDonald, Mohr, Dichter, & McDonald, 2013), the two protocols, Descriptive Consultancy protocol and Success Analysis with Reflective Questions protocol, have historically been applied in the K-12 education community (Yau & Lawrence, 2020). The Descriptive Consultancy protocol (Mohr, Parrish, & Taylor, 2019), originally developed by Nancy Mohr and revised by Connie Parrish and Susan Taylor in August 2013, was modified by McDonnough and Henschel (2015) and has been adapted for this project to help presenters think more expansively about a particular, concrete dilemma and get advice from other teams members on how to resolve it. This Modified Descriptive Consultancy (MDC) protocol has two main purposes—to develop participants' capacity to see and describe the dilemmas that arise in their work and to help each other understand and deal with them and thus lead to positive outcomes. The Success Analysis with Reflective Questions protocol (Johnson, 2019), developed by Vivian Johnson, was created to help groups or teams learn from successes and share best practices through structured discussion. The protocol was modified for this project by changing the reflective questions and adjusting the time allotted for each protocol activity to give the presenter and the consultants an opportunity to think about the context and environment in which the successful practice was executed and also how the practice can be adapted and implemented in the partner institutions' classrooms, departments, or projects.

The MDC protocol allows the problem to be framed and then reframed to enable and empower the presenter to move towards a focused solution. As stated by Mohr, Parrish, and Taylor (2019), the protocol "recognizes that the best advice is the least advice, and that helping to define and set the problem is what is truly helpful in reaching resolution.…It asks us to practice being more descriptive and less judgmental" (para. 1). The Modified Success Analysis with Reflective Questions (MSA) protocol gives the presenter an opportunity to share a success that proved to be highly effective in achieving an outcome important to them. As stated by Grove (2019), protocols like MSA work "in the spirit of appreciative inquiry," to allow presenters to "share professional successes with colleagues in order to gain insight into the conditions that lead to those successes, so participants can do more of what works" (para. 1). These two protocols differ in their format and function; however, together they create a comprehensive framework for structured engagement. The MDC protocol helps address issues a team member is facing, and the MSA protocol allows for a best practice to be shared and potentially adapted and implemented at other partner institutions. Both the MDC and MSA protocols give all participants an opportunity to reflect on the information shared and consider how that knowledge can be adapted to or used directly in their own institutional context.

Modified Descriptive Consultancy Protocol

During the Modified Descriptive Consultancy protocol, the "presenter" and the "consultants" follow a timed, eight-step process (see Table 1) during which the problem is shared by the presenter first. Then clarifying questions are posed by the consultants in order to uncover different dimensions of the problem and potentially reframe the problem. The presenter then answers the questions, and the consultants follow with a description of what they understand the problem to be and pose any additional questions they may have. Next, the consultants engage in a brainstorming session of possible solutions. The presenter reflects on the ideas. The session ends with all members engaging in a debriefing, where the facilitator asks participants about the MDC process and the roles they assumed during the protocol. In addition, the participants share their thoughts about the exploration of the problem, the proposed solution, and how the information they learned may apply to their own context. The activity provides direct advice to the partner presenting the challenge and also gives other participants an opportunity to reflect on issues at their own institutions and how they might address similar situations.

Table 1
MDC Protocol

Step	Presenter	Consultants	Time
1	Describes the problem and lays out all different dimensions. For example, did you attempt to address it already? If so how and what were the results?	Listens quietly and takes notes as needed.	3 min
2	Quietly listens and takes notes, if needed.	Asks questions of the presenter. Considers what information is missing in order to address the problem.	2 min
3	Responds to questions.	Listens quietly and takes notes as needed.	3 min
4	Listens quietly and takes notes as needed.	Each of the consultants describes what he or she heard in the presentation of the problem with statements like: • What I heard you say was… • It is still unclear because… • I would like to know more about… The consultant may pass if his/her reflection has already been shared.	5 min
5	Responds to the consultants' expressed understandings and provides further clarification of the problem if needed.	Listens quietly and take notes as needed.	3 min

Step	Presenter	Consultants	Time
6	Listens quietly and takes notes as needed.	Brainstorms possible solutions or next steps. Presents ideas in the form of questions like: • What if…? • Have you thought about…? • Would ____ be a possible solution? • I heard/read about…	10 min
7	Reflects on the advice of the consultants. Shares ideas by responding to questions like: • How might you be thinking now as a result of what has been said? • Did you gain any new insights? However, the presenter does not need to answer any questions.		5 min
8	Presenter and/or consultants share what they learned that would be useful to their institution or project		5 min

Modified Success Analysis with Reflective Questions Protocol

The MSA protocol (see Table 2) follows a similar structure during which a "presenter" shares a successful practice they have implemented at their institution and the "consultants" provide contextual feedback. The presenter gives an overview of their successful activity, which is followed by group analysis and observation about what made it a success. All observations are compiled and reflected upon by the group (presenter and consultants) to envision how the activity or practice could be duplicated within their own institutional setting. Furthermore, the MSA protocol is used to more fully understand why a specific practice works, and it thus allows individuals to apply this understanding to their future practice.

As stated previously, these protocols have been used at each of the annual meetings of the SUMMIT-P consortium and during several of the PI meetings. While the MSA protocol has not been used as frequently as the MDC protocol in the SUMMIT-P projects, consortium members appreciate both protocols and the resulting positive influence the discussions have had on the work of SUMMIT-P. Six vignettes from consortium members are shared below, describing their dilemma or success and what they gained from the experience by being a "presenter" in the protocol.

Table 2
MSA Protocol

Step	Presenter	Consultants	Time
1	Shares a case of a successful practice in the implementation of the grant (e.g., activity, lab, project, collaboration, or assessment).	Takes notes.	5 min
2	Engages in discussion on insights about what made this a successful practice. Answers any questions about the environment, incentives, context, etc.	Offers insights into what made this case of practice successful for the presenter and their institution. Share information like: • What you think the presenter may have done to contribute to the success? • What other factors may be involved?	5 min
3	Compile a list of characteristics which contributed to the success of the case including: • Tactics - activities, actions (e. g. classroom visits, weekly meetings, etc.) • Behaviors - ways in which you do your work (e. g. build trust, follow-through, responsive, being respectful, shared priorities) • Environment - (e. g. freedom to experiment in your classroom, institutional support)		10 min
4	Reflect and discuss how might we apply what we learned in this protocol to other parts of our work.		5 min

Modified Descriptive Consultancy Protocol Vignettes

The three vignettes presented in this section provide examples of problems shared during the MDC protocol (see Table 1) and the resulting impact the activity had on the presenters' projects. Two vignettes are from consortium institution PIs (one presenter for each case), and the third is from the SUMMIT-P evaluation team (three presenters). The consultants, usually 10 – 15 people for each vignette, were project management team members, institution PIs and co-PIs, and other consortium team members.

San Diego State University Example—You Are Not Alone

Within the SUMMIT-P project, the work at San Diego State University (SDSU) is focused on two mathematics courses: Precalculus (for students completing an engineering track) and Calculus (for students completing majors in the life sciences). The SDSU team's goals are (a) to identify mathematical topics from partner disciplines that instructors indicate students are weak in or to identify discipline-specific areas where mathematics is used to model phenomenon or systems, and (b) to improve students' view of mathematics as a modeling language for science. Both courses are taught in large lecture formats (approximately 150 students per lecture) with small breakout sections that meet once per week. The question for which the presenter and SDSU PI, Dr. Janet Bowers, sought guidance was how to design and implement engaging labs for the breakout sections of Precalculus that met the goals outlined above.

During the first step of the protocol, Dr. Bowers described the challenges she faced while implementing the project at SDSU. She presented four aspects: (a) the large number of students who take the course, (b) varied instructor participation, (c) a required time limitation of 50-minutes per lab, and (d) the low level of student engagement. Precalculus is taken by about 850 students at SDSU in the fall semester and the course is taught primarily by part-time lecturers. The low level of student engagement is attributed to several factors including common freshmen issues with adjusting to the university experience and students' beliefs that they have learned all of the mathematics concepts covered in the course in high school. The strategy of the SDSU SUMMIT-P team was to work with client discipline partners to develop and offer modeling-based labs for the course and to provide students with opportunities to hear from the "faces of the future"—that is, the professors that will teach the courses in their majors. These professors present short lectures on subjects (e.g., pH-levels) that the students will encounter in their future courses and subsequent careers. Bowers shared that the SDSU team had collected data on students' reactions (mediocre engagement, mild interest, not connecting as anticipated with the content, etc.) to the labs and shared the data during the session with the group.

After hearing the case, the consultants asked clarifying questions during steps 2 – 4 of the protocol (see Table 1). From Bowers's perspective, this phase of the protocol was amazingly generative. The consultants listed more constraints than she had considered. For example, one consultant pointed out that the lab instructors might need some professional development. Dr. Bowers agreed. The labs are taught by undergraduate learning assistants (ULAs) who are math majors. Another consultant pointed out that the labs might need a hook to catch students' interest by presenting a "need to know" for the content. The facilitator (who also participated in the session as a consultant) pointed out that the diversity of majors in the course—for example, some students are studying engineering while others are biology majors—might cause some students to be less interested if the application is not directly applicable to their major. Another consultant suggested that the SDSU team might want to create more realistic examples that practitioners (scientist, engineers, etc.) may or have encountered in their work. Some of the comments shared during this step were both humorous and enlightening.

The iterative process of asking clarifying questions and responding to those questions, and then going through the process again before offering solutions, provided more opportunities for reflection and allowed for a deep exploration of the full scope of the issue. In the end the clarifying questions seemed to coalesce around two different issues: (a) the selection of lab topics that are fabricated and discipline-specific versus those that feature real life situations and (b) the focus on the study of applications versus understanding abstract mathematics concepts. Once the problem was narrowed down to these two issues, the brainstorming session (see Table 1, step 6) generated several ways for the SDSU team to address the problem. Two consultants pointed out that sometimes a puzzle—even if it is abstract—can be cognitively appealing for students. There is an intrinsic motivation to solve or work on something that seems reachable. The key is to create problems that focus on precalculus content and also have "low floor, high ceiling" properties so that all students have an "on-ramp" to solving the problems, and yet there are also many ways to develop solutions. Another consultant noted that there are topics that may resonate more with 18 – 24-year-olds. In other words, she suggested that the presenter consider whether students would rather investigate questions such as “Why do you vomit blood?” or “How long does one drink take to metabolize in the body?” instead of pH levels in a pond or some other abstract concept. At the end of the session, Dr. Bowers shared during the reflection stage that both of the “real life” topics one consultant mentioned (i.e., vomiting blood and metabolizing drinks) are currently addressed in the Calculus course. While Dr. Bowers’s focus is on discipline specific, modeling-based labs, she was encouraged by some suggestions in the discussion that, if they are designed well, some labs designed on topics that are not directly connected to a content discipline can still be useful. After the session concluded, Dr. Bowers took an additional step by classifying all of the comments she had received. She organized them in three groups: (a) topic selection, (b) implementation issues, and (c) deeper engagement with the client disciplines in the course labs.

As a result of the MDC protocol, the SDSU team was able to make a number of changes to the Precalculus course. In particular, the team has developed PowerPoint presentations for the Precalculus instructional leaders to use during the laboratory session, and they also have arranged to have the laboratories co-led by experienced and novice ULAs together. Finally, given that the focus for the SDSU team during year three (with an eye toward sustainability) will revolve around the creation of Learning Glass (Learning Glass, 2020) videos that feature either professors or near-peers describing an application of mathematics in their fields, the insights garnered during the MDC protocol will inform the development of content for the Learning Glass videos.

In reflection, Dr. Bowers’s take-away message from the overall MDC experience was that, while the suggestions were very helpful, the most valuable part was the personal aspect of the experience. The whole group that engaged in the protocol session was listening and empathized with the problems she faced. Dr. Bowers reflected that, even when working as part of a team, a faculty member can feel very isolated and that egos or professional expectations can prevent colleagues from admitting that they are struggling. The opportunity to feel comfortable while 12 knowledgeable, busy colleagues actively engaged in the session was a profound and professionally enriching experience.

Oregon State University Example—The Importance of Talking to Colleagues

Oregon State University’s (OSU) original focus in SUMMIT-P was on a college algebra course. More than 40% of students who enroll in College Algebra at OSU are pursuing STEM majors. Historically, College Algebra at OSU and at other institutions across the country has not included meaningful connections between mathematics and other STEM disciplines. Since Dr. Mary Beisiegel (the PI for the SUMMIT-P OSU project) was involved in the redesign of the course from 2012 to 2015, it seemed to be a good focus for the OSU SUMMIT-P work. In 2016, the structure of College Algebra had become a patchwork of mathematical concepts lacking continuity and not efficiently aligned with the content a student needed to master to be successful in subsequent courses. OSU’s project goals were to improve the connections between the content in College Algebra and the content covered in biology and chemistry courses. In their first steps, the team sought to understand which mathematical skills the partner disciplines wanted students to develop, what mathematical topics could be easily exemplified using content examples from biology and chemistry, and what mathematics concepts are important for work in biology and chemistry. However, the OSU PI was struggling to engage the OSU partner disciplines in the project, thus making only minimal progress on the goals identified by the OSU SUMMIT-P team. In addition, a number of other partner disciplines required College Algebra, thus other stakeholders had interest in the content of the course. By January 2018 at the SUMMIT-P annual meeting, it was clear that the project could use some help from others on the SUMMIT-P team. Thus when Dr. Hargraves and Dr. Hofrening, SUMMIT-P co-PIs who are also faculty in partner disciplines, asked at the annual meeting if anyone from the consortium wanted to present a challenge they were facing using the MDC protocol, Dr. Beisiegel volunteered to present the challenges she faced while implementing her project.

During the protocol Dr. Beisiegel shared the major outside influences on College Algebra that made it seem no longer feasible to work on the course, the difficulty she had engaging with partner discipline colleagues at OSU, and her struggle to understand the role of the site PI and what she could do to make progress on this project. During the first four steps of the protocol (see Table 1), Dr. Beisiegel described the issues and the consultants asked clarifying questions. As Dr. Beisiegel reflected on the experience, the consultant questions that had the most significant impact on her included: (1) Can you find a passion for something you have more control over than College Algebra? (2) Is the work on the course important and meaningful to the collaborators? What time and resources do they have to devote to the project? (3) Are there other avenues you could use to get the work done?

During the brainstorming stage of the protocol, some of the important and encouraging advice she received was to rely on students to assist with the work, keep up with meetings and meeting reminders (including using a system to automatically remind people about meetings), and develop a management skill set. Based on the feedback during the protocol, Dr. Beisiegel reconsidered the College Algebra focus and instead considered focusing on a different course which would allow the project to incorporate the existing structures at OSU and involve other OSU colleagues who would be enthusiastic partners on the project.

The OSU team is now working on a differential calculus course. An in-depth explanation of the switch in focus and the outcomes of the OSU SUMMIT-P project can be found in Beisiegel (2020). Differential Calculus is required for engineering majors, the largest group of majors in the College of Science, and for other majors in public health fields. Differential Calculus is taught in large lecture sections (approximately 110 to 150 students per section) that meet for three, 50-minute periods each week. The lectures are supplemented by an 80-minute recitation section that meets once each week. The OSU team hired three undergraduate students (majoring in bio-health sciences and engineering) to develop in-depth problems for the course, primarily to be used during the recitations. Faculty from the partner disciplines provided feedback to the problem development team. They described how calculus concepts and skills could be used to solve problems in their disciplines. Then the faculty reviewed and revised the problems. The OSU team then implemented the problems in the course. From Dr. Beisiegel's view, the discussion and feedback that she received through the MDC protocol was invaluable. The consultants were able to see paths that she was unable to see. Through the experience, she felt supported, encouraged, and empowered to move forward. After changing the focus of the OSU SUMMIT-P work from College Algebra to Differential Calculus, Dr. Beisiegel was pleased with the progress the team made in the subsequent year.

Evaluation Team—When Just Asking Isn't Enough

The focus of the SUMMIT-P evaluation is on documenting how faculty members change in their instructional practice, teaching philosophy, and engagement with faculty in other disciplines as a result of participating in the project. To understand this change, the project evaluation team is examining data from site visits, interviews, focus groups, and surveys but most importantly from a set of "prompts" sent a few times a year to project participants—the PIs and co-PIs—that require them to write one or two paragraphs in response to the questions. Some examples of the prompts include "What was your biggest challenge to overcome while working on the project so far?" and "Think back to your early teaching experiences compared to the present. Describe a way in which your teaching has changed. What were the reasons for that change?" By examining the responses to these prompts over time, they intend to explore the conditions that contribute to or inhibit different aspects of change in the faculty.

At a virtual meeting of the project PIs in summer of 2018, the evaluation team presented a challenge through an MDC protocol session. During the first stage of the protocol, the evaluation team described the challenge. Simply stated: they were getting poor response rates to the required prompts from the participants. Typical response rates were about 25%. This was measured by determining who responded by the due date without needing to be reminded by the evaluation team. While this rate may be acceptable for surveys for which there is no incentive to participate or for participants without a vested interest in the outcome of the project, it was not acceptable for this project. When individuals agreed to participate in the SUMMIT-P project, the evaluation team assumed it was clear that all investigators would contribute by responding to the prompts. Multiple reminders were sent to individuals and institutional PIs. The evaluation team explained the need for full participation during several online meetings, but none of those efforts resulted in significantly higher participation rates.

From the evaluators' perspective, participating in the MDC protocol produced a very successful outcome. During both the clarifying questions stage and the brainstorming stage, the process was uncomfortable at times for the evaluation team. Some of the suggestions were critical of the evaluation team and were difficult to hear, but what emerged from the activity was a very practical approach to the problem. The participant response rates have significantly improved. The consultants identified a concern with the original response system. The PIs did not know which of their institution participants had responded to a prompt. They also noted that prompts being sent via email were more likely to get lost in the shuffle and could be difficult to find when an individual sat down to respond to a prompt.

Through the MDC protocol, the idea emerged to create a real-time response submission system using the Google Suite. A Google Form was developed to simplify the submission process. The result was the use of a single web link where participants could go at any time to write a response and also, when necessary, submit responses to past-due prompts. The evaluation team also created a digital check-in system for PIs so they would know who on their team had submitted responses to all available prompts in real-time. The new system provided transparency for the project participants and shifted the accountability for faculty participation to the PIs of the partner institutions. This allowed the evaluation team to focus on analyzing the content of the responses instead of collecting late submissions. Many of the participants still require reminders before completing their submissions; however, the reminders now come from the PIs at the institutions instead of from the evaluation team. The evaluation team believes that these reminders are more useful because they are coming from someone the participant knows and works with on a daily basis.

Modified Descriptive Consultancy Summary

As can be seen from the vignettes presented in this section, team members are facing challenges in the implementation of their projects. With a large, multi-institutional consortium, these challenges can be disparate, and team members can feel isolated. However, by using the MDC protocol, which can be applied in various contexts, the SUMMIT-P team members are able to draw on the collective and varied expertise of the consortium members to make substantive progress in identifying potential paths toward to achieving the consortium goals.

Modified Success Analysis with Reflective Questions Protocol Vignettes

The three vignettes presented in this section provide examples of problems shared during the MSA protocol (see Table 2) and the resulting impact the activity had on the presenters' projects. The vignettes are from consortium institution PIs and co-PIs. Either one person (the PI) or a team of people from mathematics or the partner disciplines presented the successful practice. The consultants, usually 10 – 15 people, for each vignette were project management team members, institution PIs and co-PIs, and other consortium team members.

Ferris State University—A Spin-off of Backward Design

Through the SUMMIT-P project, Ferris State University (FSU) is revising its two-semester quantitative reasoning course sequence called Quantitative Reasoning for Professionals (QRP). QRP was originally designed for business students, and the course sequence was developed through a partnership between mathematics and business faculty. The course is inquiry-based and uses scaffolded explorations for each daily lesson. Each exploration is couched in one or more realistic applications. Through the SUMMIT-P project, FSU is broadening the audience for QRP to include students completing degrees in the Health Professions and Social Work. Rhonda Bishop is the co-PI representing Nursing and Mischelle Stone is the co-PI representing Social Work. The project goals include (a) adding social justice and health contexts into QRP and (b) adding the mathematics concepts and contexts from projects developed for QRP into the partner discipline courses.

During an enactment of the MSA protocol, the FSU team shared one of their greatest SUMMIT-P project successes: developing rich contexts for their QRP course. As the FSU team started their work, they decided they were going to add case study explorations and role-playing simulations to the course sequence. During their first three-hour project meeting, the team members brainstormed possible contexts and applications related to business, health, and social justice. In that first meeting, the team ended up filling two whiteboards with ideas. They found that the richest applications integrated all of the disciplines. They selected those applications to use in case studies and simulations. They then considered the characteristics of good simulations and classified the simulations and their respective case studies based on those criteria.

By sharing this success, the presenters and consultants discovered a practical, collaborative approach to finding realistic contexts for teaching mathematics concepts. The observation stage of the MSA protocol (see Table 2) uncovered that the FSU approach started with brainstorming possible applications in the partner disciplines instead of initially focusing on mathematics concepts for which to find applications. The FSU team explained that one reason for this approach was pragmatic: that summer Dr. Bishop and Dr. Stone were in the process of learning about the QRP course sequence, which is quite unique. They further shared that a more fundamental reason was based on the "applications first" ethos inherent in quantitative reasoning. The team has extended their success with this approach at FSU by incorporating it into the work of a faculty learning community (Bishop, Piercey, & Stone, 2020). During the MSA reflection step, in which participants discuss how this success can be adapted to their context, the FSU team and consultants discussed ways in which others can take a similar "application first" approach. For flexible courses such as quantitative reasoning, they expected that this will be quite effective. For other courses, such as calculus, that have a more rigid syllabus, they hypothesized the approach may not work as well.

Augsburg University—Making It Relevant

At Augsburg University mathematics faculty are partnering with faculty in chemistry and business to revise the three-semester calculus sequence based on the CF recommendations (Ganter & Barker, 2004). Two of the themes identified from the recommendations are contextualizing problem solving and active learning, which align with Augsburg's curriculum and commitment to student learning. The goal of the collaboration with partner disciplines at Augsburg is to increase the relevance and frequency of applications involving contexts from the partner disciplines in the calculus courses. The Augsburg team consists of a core group of mathematics faculty and two partner discipline faculty (one from chemistry and one from economics) who meet regularly to develop and adapt materials to be used in the quantitative labs. The purpose is to have the labs be a significant feature of the calculus sequence.

During the MSA protocol (see Table 2) session, mathematics faculty member Dr. Jody Sorensen and chemistry faculty member Dr. Joan Kunz shared their work to develop materials for a new lab for Calculus 1. An important factor which aided in the development of the new materials is the culture of cooperation which exists at Augsburg across disciplines. Augsburg University is a small liberal arts university where most faculty know each other by name and collaboration across disciplines is promoted and valued by the institution. For example, the tenure policies and procedures at Augsburg allow promotion and tenure committees to acknowledge, recognize, and give weight to these collaborations. Another factor which led to the success of the work by the Augsburg team is that the work was completed in the summer. This allowed for participants to focus on the work, with meetings taking place every day between mathematics and partner discipline faculty. The focused conversations led the Augsburg team to examine the ordering of topics in the calculus course sequence and make changes to correspond with when students would need to use the calculus knowledge and skills in partner discipline courses. Finally, the success achieved by Dr. Sorensen and Dr. Kunz in this work was based on finding an interesting topic in chemistry which then led to discussions about the mathematics concepts needed to understand the topic. Thus, it was the partner discipline topic which drove the course material development. The mathematics concepts and skills were incorporated in the lesson or activity as tools for students to understand the topic.

Through the probing questions section of the protocol (see step 2 in Table 2), the consultants identified several features which contributed to the success of the work at Augsburg University. First, a campus culture that is steeped in collaboration creates an environment where cross disciplinary collaborations are rewarded and can thrive. While the consultants could not replicate this unique climate at their institutions, they could create opportunities for collaboration to occur, for example during the summer, when schedules are more flexible and there are fewer competing commitments for faculty. They could also think about ways to report the project work on their annual evaluations so that the department chair or a supervisor would recognize the value of the SUMMIT-P work in terms of promotion and tenure metrics. Finally, the consultants recognized how working on common ground by exploring compelling and interesting topics in the partner disciplines resulted in a nexus point at which the partner discipline and mathematics faculty could develop relevant examples for teaching concepts important to both disciplines.

Saint Louis University—Giving Them What They Want

The Saint Louis University (SLU) mathematics department has a long-standing partnership with the SLU Chaifetz School of Business. For over a decade, Dr. Michael May, a faculty member in the mathematics department and PI on the SLU SUMMIT-P project, has partnered with his colleagues in business to develop a Business Calculus with Excel course for students majoring in business fields (accounting, business, finance, etc.). This collaboration provided the foundation upon which the current SUMMIT-P work at SLU is built. Dr. May is partnering with business faculty to develop other required mathematics courses for students majoring in business fields. Given the success of prior collaboration, Dr. May volunteered to use the MSA protocol (see Table 2) to share the activities and processes by which the new College Algebra for Business was developed.

During the first step of the MSA protocol, Dr. May described the origin of the collaboration with the School of Business. He then described the process by which the focus on College Algebra for the SUMMIT-P project was determined. The mathematics faculty and business faculty created a workgroup during which they would discuss topics that the business students needed proficiency in to be successful in their business classes. During the meetings, faculty also identified gaps in the students' skills that needed to be addressed. Initially Dr. May believed that the SUMMIT-P project would focus on Precalculus, but through the faculty workgroup, he learned that most of the topics identified were actually covered in College Algebra. Furthermore, since the business faculty were primarily leading the workgroup, the dean of the School of Business was supporting the work by providing a salary supplement for participating faculty.

Through the probing questions section of the protocol (see step 2 in Table 2), the consultants identified several features which contributed to the success of the work at SLU. Consultants believed the administration's support of the partnership was vital. The monthly meetings and the engagement of multiple faculty in both disciplines facilitated the success of the project.

Modified Success Analysis Summary

The opportunity to share, adapt, and implement best practices is important to the continuous improvement of the SUMMIT-P project. The consortium achieves this in a variety of ways, including site visits, publications, presentations, poster sessions, webinars, etc. The MSA protocol is yet another way to share, adapt, and implement best practices. As seen in the vignettes, the MSA protocol provides opportunity for the group to collectively explore successful practices and consider ways to adapt them to their context.

Summary

As can be seen from the vignettes presented above, the MDC protocol provides a structured format for PIs to address what may seem to be intractable challenges in their projects. By providing space, time, and structure for the presenter to both flesh out and reflect on the challenge through a process involving probing questions, the presenter and the consultants are able to drill down into the challenges. At times during an unstructured back and forth exchange, neither party fully hears what the other person is saying and thus is unable to get to the root of the challenge. This protocol addresses that issue. In this protocol all of the questions are posed at one time. The presenter must write them down before responding. This also allows the consultants to think through several questions and the presenter to reflect on possible answers before responding. During the brainstorming stage of the protocol, time is devoted to open and uninhibited ideation, and throughout the process, ideas build upon each other. Furthermore, by closing the session with an opportunity for reflection, the consultants are able to think about how the ideas posed can be used within their own institutional contexts.

The MSA protocol provides a structured format for sharing successful practices. Most academics are used to this information being conveyed in a poster, presentation, TED Talk, paper, etc. This protocol allows for the traditional sharing of information but also for the consultants and presenter to think about why this worked so well within their institutional contexts. By engaging in that process, including the consultants describing the specific behaviors and underlying principles that contribute to the success of the practice, all of the participants are able to reflect on and think about how to implement or possibly adapt all or aspects of the example at their institutions.

These two protocols provide a structured format for the SUMMIT-P multi-institutional consortium to provide feedback to partners who are seeking advice on a challenge they are experiencing and for partners to share their success stories.

Acknowledgment

This paper was developed in part through the project *Collaborative Research: A National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships* (SUMMIT-P, www.summit-p.com) with support from the National Science Foundation, EHR/IUSE Lead Awards 1625771, 1822451, 1942808. The opinions expressed here are those solely of the authors and do not reflect the opinions of the funding agency.

References

Beisiegel, M., Kayes, L., Quick, D., Nafshun, R., Lopez, M., Dobrioglo, S., & Dickens, M. (2020). The process and a pitfall in developing biology and chemistry problems for mathematics. *Journal of Mathematics and Science: Collaborative Explorations, 16,* 92 – 106. https://doi.org/10.25891/zjn2-wb86

Bishop, R., Piercey, V., & Stone, M. (2020). Using a faculty learning community to promote interdisciplinary course reform. *Journal of Mathematics and Science: Collaborative Explorations, 16,* 69 – 83. https://doi.org/10.25891/c0m8-6v73

Bryk, A. S. (2010). Organizing schools for improvement. *Phi Delta Kappan, 90*(7), 23 – 30.

Ganter, S. & Barker, W. (Eds.). (2004). *The curriculum foundations project: Voices of the partner disciplines*. Mathematical Association of America.

Ganter, S. & Haver, W. (Eds.). (2011). *Partner discipline recommendations for introductory college mathematics and the implications for College Algebra*, MAA Reports. Mathematical Association of America.

Johnson, V. (2019, August 19). *Success analysis protocol with reflective questions.* From https://www.schoolreforminitiative.org/download/success-analysis-protocolwith-reflective-questions/

Learning Glass. (2020, April 6). *Learning glass*. From https://www.learning.glass/

McDonald, J. P., Mohr, N., Dichter, A., & McDonald, E. C. (2013). *The power of protocols: An educator's guide to better practice.* Teachers College Press.

McDonnough, J. M., & Hanschel, M. (2015). Professional learning community-based induction: creating support for new teachers of science. In J. A. Luft, *Newly Hired Teachers of Science: A Better Beginning* (pp. 145 – 154). Rotterdam: Sense Publishers.

Mindich, D., & Lieberman, A. (2012). *Building a learning community: A tale of two schools.* Stanford Center for Opportunity Policy in Education.

Mohr, N., Parrish, C., & Taylor, S. (2019, August 16). *Descriptive consultancy.* From https://www.schoolreforminitiative.org/download/descriptive-consultancy/

National Science Foundation. (2019, August 16). *Active award search*. From https://www.nsf.gov/awardsearch/showAward?AWD_ID=1822451&HistoricalAwards=false

Stoll, L., & Louis, K. S. (2007). *Professional learning communities: Divergence, depth and dilemmas.* Open University Press.

SUMMIT-P (2019, August 16). *SUMMIT-P home*. From https://www.summit-p.com/home

Yau, J., & Lawrence, J. (2020, April 6). *School reform initiative scope of work.* From https://www.schoolreforminitiative.org/wp-content/uploads/2014/05/SRI-Impact-April-2014.pdf