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To Map or to Model: Evaluating Dynamism in Organically Evolving Faculty Development

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Abstract
Applying interactive teaching strategies within undergraduate STEM education has become an increasingly important endeavor for faculty. However, changing teaching strategies is not always easy, even when faculty are motivated to do so. Therefore, examining faculty change processes is critical to understand how and why a teaching change has occurred. This paper examined faculty change processes and faculty outcomes during an NSF-supported faculty development project. One purpose for this study was to discuss how the project evaluation applied two different tools to understand the mechanisms underlying change and how the program components and mechanisms contributed to the project outcomes. One tool was a logic model, which is an evaluation tool. A second tool was a conjecture map, which is a research tool grounded in design science. Thus, a second purpose for this study was to explore the juxtaposition of the two tools. We compared and contrasted the contribution of each tool in terms of how the tool facilitated the evaluative understanding about faculty development processes and outcomes. Our results demonstrated that faculty development is a complex and dynamic process that can be elucidated by using multiple tools.

Keywords
Program Evaluation, Logic Model, Design Science, Conjecture Map, Faculty Development

Motivation and Background
Engaging students in learning using interactive teaching strategies has become increasingly important within undergraduate STEM education. Assistance for faculty to adopt and implement interactive teachings strategies within STEM education is critical for successful change. However, faculty development of teaching has historically been challenging [1]. Even motivated faculty may have difficulty enacting and sustaining changes [2]. Intentional design of faculty development within the context of a motivated, supportive faculty learning community is critical [3]. Faculty use of interactive teaching strategies has contributed to increasing student learning outcomes [4]. Therefore, helping faculty develop interactive teaching strategies can ultimately contribute to a stronger STEM workforce.

Laurillard argued that instructors must examine their teaching within a safe community to be enabled to improve their teaching [5]. Community offers the means for instructors to articulate their pedagogical designs and receive feedback. Laurillard also proposed community as an instructional efficiency. Adopting or adapting the designs of other instructors acts as an affordance for other instructors so that they do not have to "recreate the wheel [6]."

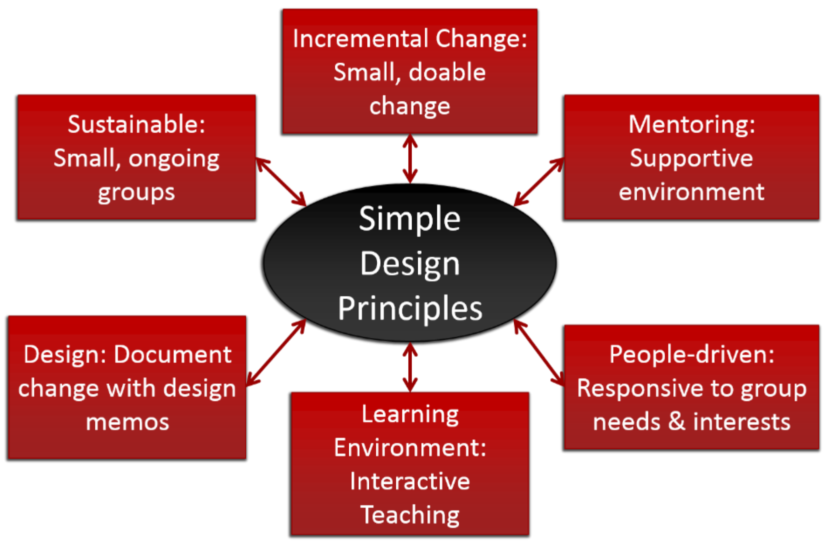
Uncovering both affordances and barriers to faculty teaching changes can support researchers, evaluators, and faculty involved with development. However, research about faculty change and the faculty outcomes of change is nascent. Therefore, examining the processes in which faculty change their teaching and the resulting outcomes for faculty is vital [6]. This paper examines the implementation and outcomes of an NSF-funded faculty development project using two different tools, a logic model [7] and a conjecture map [8, 9]. This paper extends prior work related to this project by comparing and contrasting on an evaluation tool with a research tool [10,11].

The Faculty Development Project

Prior to examining the tools used to evaluate the processes and outcomes of a faculty development project, it may be helpful to understand the project. This project was developed as a scale-up of a previous project focusing on engineering faculty's instructional changes [3]. The scale-up for this project was to expand the work to a broader set of STEM disciplines. The main hypotheses for this project were that: (a) faculty learning communities can support initiation of teaching change and faculty research about their changes; and (b) initial small changes in teaching will lead to larger changes over time.

Laurillard's conceptions of teaching as a design science acted as the basis for the project design framework. This project's design principles guiding the faculty development work were: (a) sustainability of small, ongoing communities, (b) focused on incremental change with (c) faculty being *mentored* by community leaders; (d) community discussion was driven by the needs of the *people* participating in the project; (e) based on their *learning* *environment* [12]. See Figure 1 [12].

Figure 1. The Design Principles for the Faculty Development Project [12].



Project goals included: (a) the scale-up project will be implemented and sustained across multiple STEM programs; (b) the research team and community leaders will work together to form discipline-based faculty learning communities (FLC) [13] to offer support for faculty learning about evidence-based interactive teaching strategies; (c) faculty will use one or more interactive teaching strategies within their classrooms; (d) faculty will document their interactive teaching strategy in a design memo; (e) support for faculty research about their own teaching will be provided within a faculty learning community; and (f) design memos, scholarship about teaching, and project findings will be disseminated.

To enact the project goals, four different learning communities were designed into the project and evolved as the project developed [13]. The first community was the Principal Investigator (PI) research team. This community consisted of the PI and co-PIs, the evaluator, and a graduate research assistant. This community met frequently throughout the project to reflect on and discuss progress, brainstorm additional ideas related to project implementation, problem-solve, identify potential fields and faculty for potential inclusion or expansion of the communities, and discuss research and evaluation. The second community was the community of leaders (LC) for the leaders of the discipline-based faculty development communities. The CLC was led by the PIs, with all members of the research team as participants. The CLC afforded an opportunity for the community leaders to become oriented to a faculty learning community and a safe space to discuss successes and areas for potential growth for their own teaching and as leaders of their own communities. The third community was the teaching development communities (TDCs). TDCs were faculty learning communities in which the community leader cultivated a safe environment for faculty to discuss their successes and areas of growth in teaching, as well as give and receive feedback via peer mentorship [13]. The fourth community was the teaching inquiry group (TIG). This was a faculty self-study research community, led by one of the PIs. In this community, faculty conducted research focused on a situated and chosen inquiry of their own teaching using data collected from their classroom along with their ongoing study of their role in the focused change in order to improve their students' learning. Also integral to the self-study methodology was that participants worked as peer reviewers for each other's research in a reciprocal mentorship model sharing ongoing progress of their individual self-study research project (Author, 2018). [14]. The co-constructed needs of the faculty within of the communities were intended to drive the participatory processes as was a collective self-study of the nature of their learning which participants led in a college-wide presentation (Authors, 2017). The project was designed to focus on faculty processes, including affordances supporting change and barriers to change.

The primary outcome of this project focused on *process* was intended to be the use or modification of an interactive teaching strategy within a course. From this primary outcome, faculty were invited to participate in developing two groups of products, also intended as outcomes. The first product was a design memo. The design memo was intended to be the description of an interactive teaching strategy, its implementation, and faculty reflections on implementation. Faculty developed design memos to describe their interactive teaching strategy and share their insights within their TDC community, as well as with a broader community. In addition, the design memos were developed for the instructor to document and reflect on the identified instructional change, including successes in the teaching process, and suggestions or tips for other faculty about how to best implement the strategy. Design memos were initially shared internally with other faculty via internal online storage. Design memos have now been disseminated via a website (see blinded website). In addition, all TDC participants were invited to develop presentations, papers, or articles related to their interactive teaching strategy as additional outcomes of participation in the TDCs [e.g., 15]. For faculty who wanted to extend their learning and research about their own interactive teaching strategy, the TIG created an environment to further interrogate and research their own teaching change using self-study methodology [14]. It also entailed the support of a self-study methodologist who integrated visually rich digital pedagogical strategies to enhance participants' understanding of who they are as teachers and the role they play in students' learning.

The Juxtaposition of an Evaluation Tool and a Research Tool

In this paper, we juxtapose two tools used in distinct fields, evaluation and research, to describe results of an evaluation of a faculty development project. It is critical to understand that significant distinctions define the differences between the evaluation endeavor and the research endeavor. For example, evaluation is a local activity. That is, evaluation addresses the specificities of whether, how, and why a policy, program, project, or curricula worked as intended for the given participants [16]. The purpose for evaluation is to determine the merit or worth of a program to support stakeholder decision-making related to improvement or accountability [17]. An evaluation may use both evaluation data and research data to support ultimate determinations about effectiveness, impact, or termination. A logic model is an evaluation-based tool [18].

The purpose for research is to generate new knowledge and develop theory or to develop solutions to real world problems [19]. For example, research is conducted to ascertain evidence that is generalizable beyond the intended sample [20, 21]. A conjecture map is a research-based tool grounded in design science [8, 9]. Because the project utilized a design science framework, it seemed logical to explore a design science tool as a part of the evaluation.

The Role of Logic Models in Program Evaluation

Logic models have historically been used within the field of program evaluation to help evaluators understand program components. However, logic models are increasingly expected within a proposal for many grant-funded projects. Thus, a logic model can act as both a program planning and program or project evaluation tool. A logic model visually illustrates program or project components and outcomes. Logic models can be very simple or quite complex. The simplest models outline investments, actions, and results. More complex models examine the context for the program, underlying assumptions about the nature of the program, and external factors affecting the program in addition to inputs (investments), outputs (activities and participation), and outcomes (impact) across time (short, medium, and long term) [18]. Logic models depict how a program or project intends to enact change [22].

Evaluators use logic models to examine implementation fidelity, when logic models have been developed as part of a program plan [23]. In addition, logic models can be used as a framework, to focus data collection on the specified program activities and expected outcomes, to determine appropriate methods for data collection, and to organize and interpret data in terms of a framework [22]. When no logic model exists, evaluators may develop a logic model to describe the program visually. Logic models can be a useful tool for communicating the nature of a program to stakeholders. The use of logic models has been found to contribute to clarity in goals, alignment of activities with goals, communication about the program, and learning related to evaluation [24].

The Role of Conjecture Maps in Design-Based Research

A conjecture map is a tool grounded in design-based research methods to understand learning. The purpose for a conjecture map is to describe the overall design of a research project [9]. A conjecture map is comprised of a high-level conjecture about how a program will work, as well as design and theoretical conjectures about the mediating processes contributing to learning and other changes in participants [8]. Other components of a conjecture map consist of the embodiment of the design, mediating processes, and outcomes. Design embodiment addresses the tools and materials to be used in the research, participant structures, discursive practices, and task structures. Conjecture maps are used to examine research design, conjectures about change, the mediating processes that can affect or cause change, and project outcomes. A conjecture map can be used to track adaptations in a project over time, including changes in the conjectures, implementation, or expected outcomes [9].

This research is significant because to the best of our knowledge, other studies have not been conducted that juxtapose logic models and conjecture maps. We conducted a search for the use of conjecture maps within the evaluation literature, including the *American Journal of Evaluation*, *Evaluation and Program Planning*, *Evaluation*, and *Assessment and Evaluation in Higher Education* and could find no articles using a conjecture map as part of an evaluation. To the best of our knowledge, conjecture mapping is not employed within the evaluation literature. We also examined the juxtaposition of conjecture maps and logic models within the *Journal of Engineering Education*. To the best of our knowledge, no such juxtaposition exists within engineering education. Therefore, the significance of this research is that it has the potential to add to the literature, across the fields of evaluation, engineering education, and faculty development to support understanding of learning and other processes and outcomes within a faculty development trajectory.

The purpose for this study was to compare two tools, a logic model [7] and a conjecture map [8, 9] to understand the usefulness of each tool in evaluating faculty processes and faculty outcomes within a faculty development project. A second purpose was to model the dynamism in this organically evolving project.

Methods

To collect and analyze the data to develop the logic model and the conjecture maps, we used a qualitative evaluation design [25]. For this paper, we focused on the implementation data collected during the course of the project, including the reflections of the research team throughout the project which were gathered informally during research team and CL meetings, as well as, via interviews of research team members.

Participants. A total of 49 individuals participated in this research study. Participants included the principal investigator, two co-PIs, and a research team faculty member; nine community leaders (CLs), and 37 faculty members. Four white males and five white females led disciplinary/departmentally-based TDCs. Disciplines encompassed astronomy and physics, biology, civil engineering, electrical engineering, forensic science, health sciences, and mathematics. There were two community leaders for biology due to the size of the community. There were 31 participants in the TDCs, 16 females and 15 males, 24 faculty and seven graduate teaching assistants (GTAs). In addition, there were six participants in the TIC, two males and four females.

Data Collection. Sixteen CL meetings were conducted and recorded over the course of the project. The transcripts were analyzed. The evaluator also observed the meetings, and evaluator notes were analyzed. Thirty-eight CL implementation logs or “check-ins” were collected during the community leader meetings. Sample protocol from the implementation logs included: “Share one thing that is working well in your facilitation of your TDC.”; and “Share one thing that you are struggling with in your facilitation of your TDC.”

Interviews with all community leaders were conducted, and six were analyzed. Interviews were conducted with all participants. Twenty-two interviews were analyzed[1]. Sample interview protocol addressed topics such as, leadership challenges for CLs, and changes in teaching as a result of the group experience for CLs and TDC participants In addition, eight interviews with the research team were conducted by the evaluator and evaluation students across the project period and were analyzed. Participants used the open-ended questions to describe their thoughts about how the program worked.

Design memos submitted by faculty were analyzed (N=18). Tenured professors, teaching faculty, and graduate teaching assistants submitted memos. Memos were submitted across a range of STEM content, such as astronomy, biology, environmental science and policy, and hydraulics. Design memo prompts were geared to elicit directions that faculty might give to other faculty in order to implement the interactive teaching strategy. Samples of the prompts on the design memos asked: (a) “What is the strategy?”; (b) “How is it useful for students?”; (c) “What do I need to explain to my students about this new classroom activity?”

Data were coded using emic and etic analyses [25]. Emic and etic analyses are based within anthropology and offer different perspectives to examine and analyze data. For example, the emic perspective is from the perspective of the participants [25]. For this study, the emic perspective allowed the evaluator to understand how program participants perceived the program. Emic codes were developed based on the participants’ responses. In contrast, the etic perspective is from the perspective of the observer [25]. In the project, the research team acted as observer. For this study, the etic perspective placed the evaluator as observer. The research team developed etic codes a priori to the analysis. Etic codes were based on the design principles.

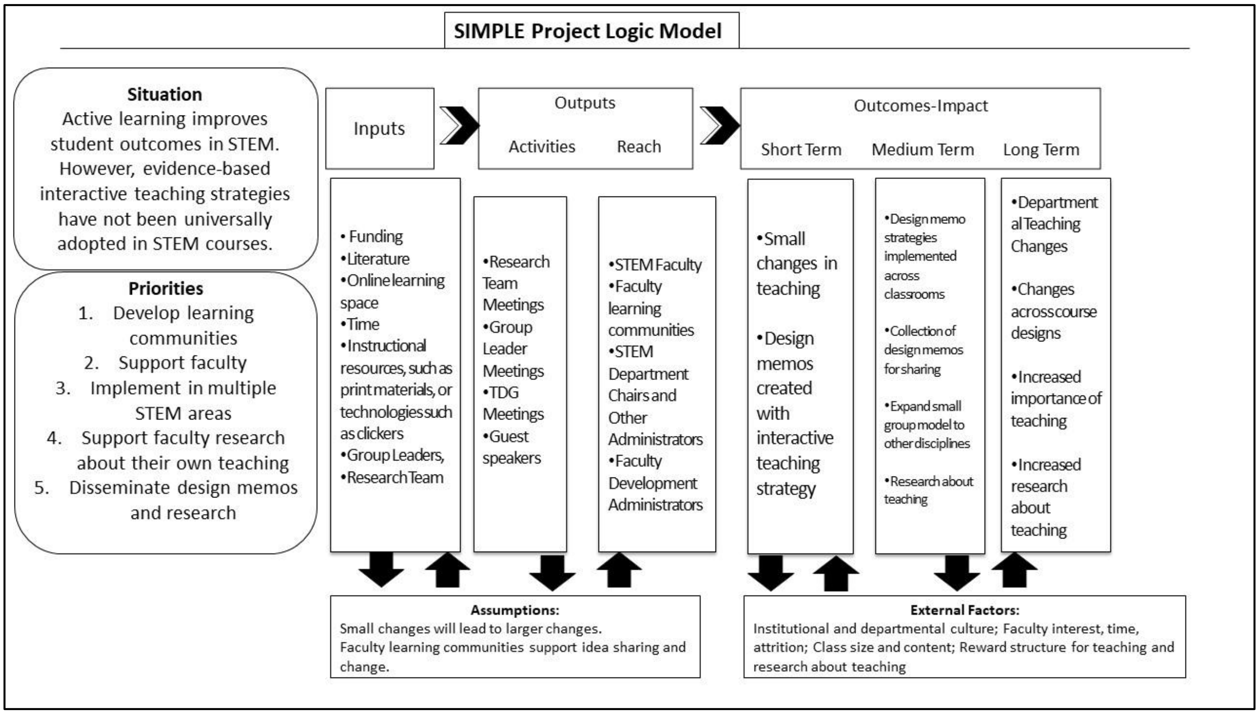
Findings

Three graphic representations were developed based on all of the data collected: a logic model [7] and an initial and final conjecture map [8, 9]. Both types of graphic representations were used to examine, describe, and illustrate the hypotheses, design, implementation, processes, and outcomes of the faculty development project. In general, though not exclusively, etic analyses were used to develop the logic model, while emic analyses were used to develop the conjecture maps.

Logic Model Utility. Initial results indicated that the logic model was a useful document for planning during project implementation. The logic model also assisted with recognizing expected inputs and with examining implementation of expected activities and strategies to support faculty development. The logic model was also helpful in clarifying the expected proximal, medial, and distal outcomes. The logic model also addressed the context driving the project, external factors impacting the project, and assumptions underlying the project. See Figure 1. SIMPLE Logic Model.

[1] Interviews are continuing to be transcribed and will be analyzed as they are completed.

Figure 1. SIMPLE Logic Model.



Conjecture Map Utility. The initial conjecture map was used to examine the initial design decisions including the high-level conjecture for the project. In addition, the conjecture map was used to specify materials and tools, structures for tasks, participant engagement, and discursive practices. We also used the initial conjecture map to show the design conjectures about the relationships between the embodiment of the SIMPLE design and the mediating processes supporting faculty development. Finally, we used the conjecture map to show the theoretical conjectures about the relationships among the mediating processes and outcomes. See Figure 2. Initial Conjecture Map.

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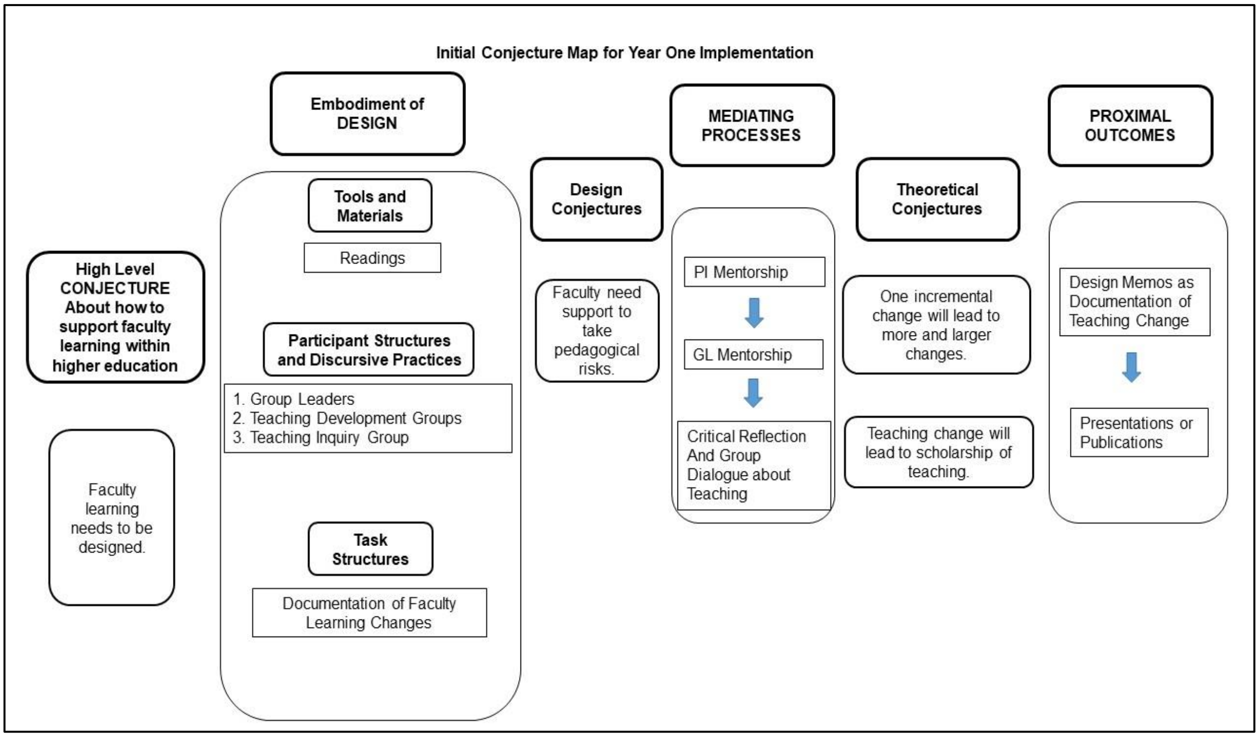
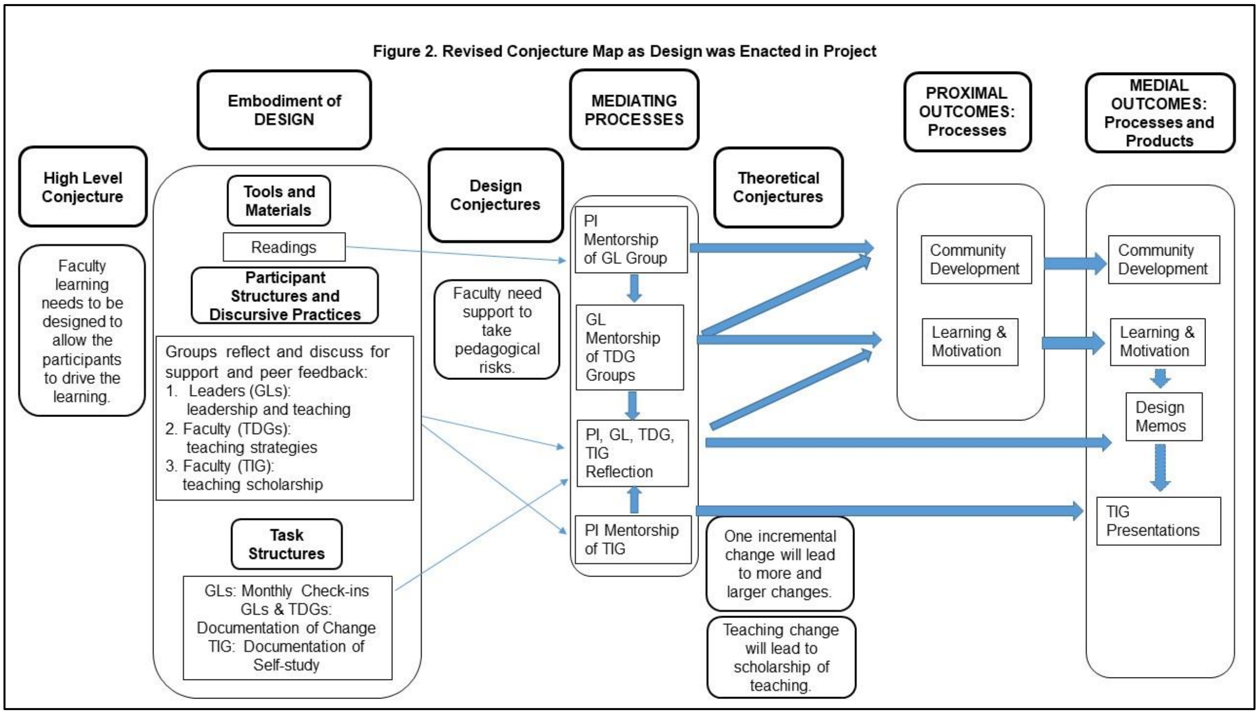


The design and theoretical conjectures, as well as the mediating process and outcomes, were examined with the conjecture map to follow the evolution of processes and outcomes. To capture the dynamic nature and flow of the faculty change processes across time, a second conjecture map was developed to model those changes. See Figure 3. Revised Conjecture Map as Design was Enacted in Project.

Figure 3. Revised Conjecture Map as Design was Enacted in Project.



Comparing the Logic Model and the Conjecture Maps. The logic model and conjecture maps have several strengths in common. They can both be used as a planning tool. They can both be used to examine implementation of the program design, though in different ways. They both can be used to support program evaluation.

The logic model revealed context that the conjecture map did not. In addition, the logic model more completely identified input, participants, activities and outputs as a function of the project. That is, the focus for a logic model is on the actions engaged and resources used by program or project personnel to elicit participant outcomes cognitively as proximal outcomes, behaviorally as medial outcomes, and systemically as distal outcomes. However, the logic model has been historically treated as static.

The conjecture map exposed program processes that the logic model did not. The conjecture map delineated stages of processes and outcomes for the research team, community leaders, and faculty. The conjecture map also uncovered the processes leading to the enactment of interactive teaching and research about teaching. The conjecture map captured and illustrated learning community and faculty development processes. The most significant contribution of the conjecture map was that it elucidated how processes became incremental outcomes highlighting the nature of the faculty development trajectory within the context of the disciplinary-based learning communities, which were designed to be organic and informal, in this project. That is, the focus of the conjecture maps was on the learning and motivational processes in which the participants engaged individually or with each other in community.

In the two conjecture maps, the relationships between design embodiment, mediating processes, and outcomes are explicit. Figure 3 elucidated that the first part of the faculty development trajectory was that the formation of a learning community and that the development of learning and motivational processes were the proximal outcomes. Thus, for the faculty development trajectory, developing supportive change processes are the proximal and medial outcomes that precede product development, such as design memos, scholarship of teaching, or self-study of teaching.

The, a primary difference between the logic model and the conjecture map is the attentional focus -- the program (logic model) or the participants (conjecture map). Therefore, the application of each type of model may depend on the formality related to the learning environment. Programs by their nature are considered as formal learning environments, for example. However, within this formal project, the implementation was informal related to each of the multiple organic faculty learning environments that were implemented.

Discussion

There are multiple unique advantages and disadvantages associated with each tool. For example, one strength of the logic model is that it is an excellent planning tool to begin to understand program theory [26]. In addition, the logic model situates the program within a local context, ensuring that stakeholders have an understanding of the situation, the assumptions underlying the program, and the external factors affecting the program. Another strength of the logic model is its facility to be used as a tool to monitor implementation fidelity for programs that are to be implemented as the design intended, without variation. The logic model very clearly explicates the program investments, functions, and intended outcomes over time. The categorization of outcomes as proximal, medial, and distal provides the evaluator with the opportunity to monitor which expected outcomes have been attained at a given point in time. Thus, the logic model functions as a guideline for formative and summative evaluation purposes.

There are also disadvantages to the use of logic models. Logic models do not have a means to capture the functioning of program processes, distinguish mediating processes or show how activities or strategies work together. Another weakness is that logic models do not show relationships. A logic model is a “graphic representation of a program showing the intended relationships between investments and results” (19, p. 4). However, the relationships within logic models are implied rather than overtly indicated. Further, logic models historically have been considered to be fixed. Program theory, implementation fidelity and outcomes are examined against the model. That is, logic models are intended to represent how the program *should* function as generalizable across program sites. Logic models were not intended to capture the nuances of program implementation as a local event. Logic models are an effective tool for program planning and evaluation. However, they were not developed as a means to capture organic, dynamic, or local processes.

The strength of the conjecture map is that it charts the trajectory of a developmental or change process and how that process leads to specific outcomes. Another key advantage of a conjecture map is that it is dynamic. A principal feature of design science is expected adaption [27, 28]. Therefore, conjecture mapping was developed specifically to adjust to adaptation, tracking programmatic changes such as changes in the design of a project (design conjectures), changes in program processes, changes in theoretical conjectures about how and why learning occurs, or changes in expected outcomes**.** In fact, there is an expectation that the project will adapt as needed. Because adaptation is expected within design-based research, conjecture maps seem to be ideally suited to depict organic and dynamic processes. In a previous paper, we discussed some of the variations in implementation [11]. Only the multiple conjecture maps could capture those mediating processes contributing to the variations across communities [10, 11].

Implications

Overcoming Evaluation Challenges. There were several evaluation challenges. The first challenge was that faculty development is a process. One initial challenge was in attempting to identify early faculty outcomes. As can be observed in Figures 2 and 3, the trajectory of faculty development is the nature of process as an outcome. Specifically, faculty outcomes are the processes in which faculty engage to enact change. Thus, over the course of the project, it was necessary to use both a logic model and a conjecture map to capture within the evaluation to show the true nature of change [10, 11].

A second challenge was the nature of faculty change. Faculty change is incremental and takes time. Therefore, changes in student outcomes cannot be expected in the early years of a faculty development project. Faculty need the opportunity to practice and develop expertise in the new strategies. Therefore, changes in student outcomes should not be expected until the later stages of the faculty change trajectory [11]. It is a success if changes in student outcomes occur earlier, but they should not be expected in the earlier stages.

The third challenge was that the project evaluator was invited to be a part of the team after the design was conceived. A logic model was not initially developed as part of the design process. Rather, the logic model was developed as a part of the evaluation. For this project, it was very easy to develop the logic model because of the clarity with which the project was conceived and described in both text and in meetings. Therefore, not having an initial logic model was not a challenge for this project, it can be for many projects where program theory is lacking. Thus, the challenge for PIs and evaluators is in ensuring that research teams, participants, and stakeholders understand how a project is intended to function. Without this understanding, there is the potential for a lack of implementation fidelity in static programs. A second component of this challenge was that the logic model was developed before the conjecture map. The challenge was that the logic model did not appear to be sufficient for capturing the nature of the program. Thus, a second method appeared to be needed to illustrate an organic change process that was dynamic. Therefore, in faculty development projects that are grounded within design-based research, it would be helpful to develop both the logic model and conjecture map simultaneously.

Modeling Change. The key differences between the two tools is the nature of the information presented, the degree of adaptation that can be represented, and the type of feedback that an evaluator can deliver using either model. One implication is that evaluation of dynamic and evolving process programs may best be served with the use of a conjecture map in addition to the logic model to explain program theory. An implication for faculty development is that we learned that the faculty development trajectory is a process trajectory where processes become proximal and medial outcomes prior to product development in which faculty document their instructional changes in some manner, such as through design memos or research about their teaching.

Conjecture maps allow for an examination of organic changes within conjectures and across implementation. In addition, conjecture maps capture the nature of learning in informal learning environments. Thus, conjecture maps elucidate the evolution of a developmental or learning process as an outcome. Feedback from conjecture maps illustrates how mediating processes can be examined and adapted to attain the desired outcomes, or to adapt expectations in outcomes. The difference between the feedback is in the degree of change in program hypotheses or conjectures, activities, and implementation strategies.

Applications of Conjecture Maps and Logic Models. Both tools were necessary to fully understand the processes and outcomes of this organic and dynamic faculty development project. The advantages and disadvantages of logic models and conjecture maps to examine faculty development are situated along three continua. Depending on where along a given continuum a project falls may inform an evaluator or PI which graphic model is most useful for research and evaluation. These continua include: a) formal-informal design; (b) a static-dynamic implementation; and c) a process-outcome-impact. Projects that are more informal, dynamic, and process oriented could benefit from the use of conjecture maps, along with logic models.

Conclusion

In this paper, we discuss the use of logic models and conjecture maps as complementary tools to support evaluation of a process-focused faculty development project. This paper extended the research within program evaluation and STEM faculty development related to potential tools that can be used to understand processes and outcomes within a faculty change process. A logic model was used to illustrate the expected progression of the project, clearly specifying inputs, outputs, and proximal, medial, and distal outcomes. However, the logic model was not sufficient to completely understand the processes and outcomes of this faculty development project. One reason that the logic model was insufficient was that the mediating processes that require participant use of outputs within activities to achieve outcomes are implied within a logic model. Within a conjecture map, the mediating change processes are made explicit. Logic models mask the cloud of conjectures about how change might happen within the participants. The conjecture map concretized the mediating processes, elucidating them as proximal and medial outcomes of a faculty change trajectory. Results of the conjecture map indicated that faculty development projects should exist on a multi-year trajectory. Both the logic model and the conjecture maps proved to be useful tools providing complementary types of information in evaluating this NSF-funded process project focused on faculty change. Therefore, for process projects, evaluators should consider using both tools.

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