2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34457

Work in Progress: Using Systems Thinking to Advance Faculty Development: A Student Success in Engineering Example

Dr. Amy B. Chan Hilton, University of Southern Indiana

Amy B. Chan Hilton, Ph.D., P.E., F.EWRI serves as the Director of the Center for Excellence in Teaching and Learning and is a Professor of Engineering at the University of Southern Indiana. Her work focuses on motivating and supporting faculty in instruction transformation to improve student outcomes, developing frameworks and systematic strategies to cultivate faculty and administrative buy-in for change, and increasing the understanding of what impact student success and retention in STEM for diverse populations of learners. Prior to joining USI, Dr. Chan Hilton served as a Program Director at the National Science Foundation with experience in the Engineering Education and Centers (ENG/EEC) division and the Division of Undergraduate Education (EHR/DUE). She also served as Associate Chair and Associate Professor in the Department of Civil and Environmental Engineering at the Florida A&M University - Florida State University College of Engineering. She holds civil and environmental engineering degrees from MIT and the University of Virginia and is a licensed professional engineer.

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Introduction

This work in progress paper explores a systems thinking approach to gather perspectives and engage stakeholders in a complex issue while also informing faculty development programs and activities. Faculty development often involves helping faculty members and departments identify, develop, and implement evidence-based instructional practices into courses and curriculum, to improve the student learning experience and student outcomes. Centers for teaching and learning (CTLs) and other offices that work with faculty also may support additional aspects of faculty work (e.g., research, service, and career advancement) and provide holistic faculty support in areas such as time management, work-life topics, and well-being [1]. From the context of the CTL, the intentional alignment of programs, in which the relationships between goals and activities of different faculty development programs are considered, helps to identify strategic approaches to advancing the CTL's goals. At the same time, from the context of faculty members, participating in exercises that encourage the consideration of an issue from both big picture and granular perspectives and the connections between the factors that impact the issue can help foster reflection and make visible the role of faculty members in the issue.

The objectives of this paper are to 1) present a systems mapping approach that can be used by faculty developers and CTLs to engage faculty, students, administrators, and other stakeholders; 2) highlight an example application of this systems thinking approach to student success and retention in engineering; and 3) explore potential benefits of systems mapping. The expected outcomes of this paper are to provide the reader an introduction to systems mapping via an example application and prompt the reader to consider using systems thinking and systems mapping in their faculty development and CTL planning or as an alternative way to gather perspectives from faculty, students, and other stakeholders. Here, the focus is on using systems mapping as a way to gather stakeholders' perspectives to help identify challenges and opportunities and motivate engagement to these issues, rather than directly seeking solutions.

Systems Thinking and Systems Mapping

Systems thinking considers how parts of a complex system are interconnected and the interactions between them. Systems thinking recognizes that elements and activities that exist in isolation influence each other and considers how their relationships might work towards a broader goal. In a system, any single element cannot achieve the goal alone. The introduction of systems thinking to an organizational development context is attributed to Senge [2] and was operationalized by Meadows [3]. Within engineering, the discipline of systems engineering seeks to improve physical components and processes to meet or maximize goals. A systems engineering framework has been applied to faculty development and engineering education transformation initiatives [4].

Systems mapping is a common and powerful tool to apply systems thinking to uncover a deeper understanding of a complex issue and identify potential solutions [5]. Systems mapping also can help refine or integrate a theory of change [6]. The systems mapping process consists of exploring factors, connections, and purpose of a complex systems and identifying feedback loops that highlight the interactions between components [3, 6]. Systems mapping is different from concept maps in that a central node is not the focus and feedback loops showing interactions and interdependencies are identified. When systems maps are developed by stakeholders involved in the system, the process also brings forth multiple perspectives to inform change [3, 5]. An example of the fundamental systems mapping process is illustrated in the following section.

Example Application: Perspectives on Student Success and Retention in Engineering

This section illustrates the application of systems mapping by a faculty developer by highlighting an example to gather perspectives and engage stakeholders on student success and retention. Student retention and success is a complex issue, with multiple factors and programs that can work together or conflict. No one program, office, or individual holds singular influence to impact student success; thus, systems thinking and systems mapping is an appropriate approach. The purpose of using systems mapping in this example is to gather information from faculty and students on what they perceive as factors impacting student success. This information was used to identify similar and varying perspectives and experiences, as well as positive aspects and opportunities. Institutional and learning data then can be used to further explore the ideas and evidence-based instructional practices and other changes can be proposed to address the issues.

The implementation of curricular changes across an engineering program and within specific courses, such as implementing active learning, other evidence-based instructional practices, and high-impact practices, can improve student success and retention [7]. At the same time, institutional programs that provide opportunities for academic support and advising, co-curricular engagement, the development of intrapersonal and interpersonal skills, fostering a student's sense of belonging, and financial assistance have been documented to contribute to student success and retention [8, 9]. Faculty members have varying recognition of the interrelationship between these supports and their role in teaching and learning. Moreover, students' perspectives often are missing in developing strategies to support student retention and success. Faculty developers can help bridge these connections and help faculty identify and implement evidence-based instructional strategies in their courses while cognizant of the broader landscape of programs that exist across the institution.

In this example, a series of systems mapping activities was conducted in 2019 by the Center for Excellence in Teaching and Learning at the University of Southern Indiana (USI, a public, regional, comprehensive university) to gain an understanding of student success and retention influences for its undergraduate engineering students. Participants included a total of 99 students in different engineering majors, who were enrolled in either a sophomore-level Electric Circuits course or a Senior Design course, and 16 engineering faculty and staff members. During each 30- to 40-minute systems mapping activity, participants were invited to identify and explore the factors and actions that impact student retention and success. During a systems mapping process adapted from The Omidyar Group [10], participants first individually responded to the question "what impacts your (or students') success in engineering?" and then worked in groups of 3-5 participants to organize their responses and draw connections between the identified factors. The faculty developer, who is an engineer by background and prior faculty role, facilitated the systems mapping process in each session. The participants were guided through the following steps to iteratively create a systems map [11] of factors that impact student success in engineering and identify the interconnections between them:

1. Start with a broad view and range of perspectives on student success in engineering:

2. Take a few minutes to individually identify: What enables and inhibits your (or students') success in engineering at [institution]? Write one element per sticky note. Use as many sticky notes as you need.
3. Add your notes to your group's easel pad sheet. Take a few minutes to silently read what others in your group have written.
4. Now work with your group to form clusters of enablers and inhibitors.
5. Label each of the clusters and add sticky notes as needed.
6. How might individual elements and clusters connect to each other? Draw arrows to show these connections and interdependencies.
7. Label the three most important factors with a star.

The six sessions resulted in 27 student- and faculty-developed systems maps of student success in engineering (Figure 1). Details of the participant groups, methodology, and preliminary analysis of the resulting systems maps are described in [11]. The systems maps, which include the student success factors identified and the connections among them, were analyzed and compared across the participant groups (e.g., sophomore- and senior-level students and faculty). The most common themes across the systems maps were related to faculty teaching effectiveness and interactions, students' personal factors (e.g., intrapersonal attributes and individual needs and priorities), and student time management. The factors also were categorized as structural (resources and practices), attitudinal (beliefs and attitudes), and relational (interactions between individuals or groups), with a similar number of structural and attitudinal factors and half as many relational factors identified.

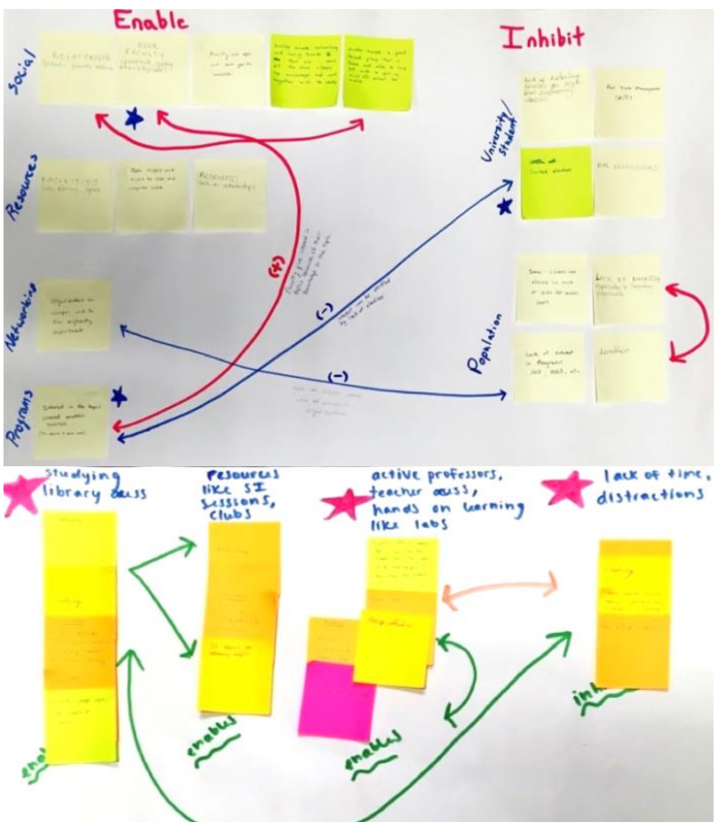

Figure 1. Example systems maps developed by engineering students in response to "what impacts your success in engineering at [institution]?"

In addition to gathering the perspectives on student success represented in the systems map to inform initiatives and changes, the facilitated systems mapping activity created opportunities for the participants to reflect on their beliefs and assumptions, interact with other perspectives, and hold conversations [5]. Since most of the systems mapping process was conducted in small groups, the facilitation encouraged participants to be open to hearing other experiences and to engage in conversations to collaboratively explore the question and create a systems map. The systems mapping activity resulted in content and conversations that likely are different than what would result from individual interviews, surveys, or focus groups, perhaps because of its, participatory, collaborative, and exploratory nature. This process also aligns with the goals of the CTL and faculty development activities by using a participant-centered and interactive approach, rather than facilitator-centered, to gathering perspectives and ideas. Future work includes conducting additional systems mapping sessions with students, with consideration of Covid-19 pandemic experiences, and comparing the factors identified by the participants at USI with factors to student success and retention in engineering identified in the literature and at other institutions.

Extending Systems Thinking and Adapting to Other Applications

Exploring student success and retention using systems thinking can help identify perceived factors that then inform areas needing attention and potential solutions. The systems mapping process can be adapted by those seeking to gather perspectives or foster engagement around a complex issue. The example described in this paper used brief systems mapping sessions, and while these activities initiated conversations and reflection, longer sessions or a series of sessions would be needed to deeply explore the issue, gain a big picture and granular understanding of the system, and identify potential bottlenecks and opportunities or theories of change. Extended sessions would spend time identifying feedback loops [6, 10] from the systems maps themes and factors. Additional activities include inviting participants to create a story of their systems map and to consider how the narratives are similar or different from their existing mental models.

The results of systems mapping have potential implications for individual faculty as they consider their course design, instructional practices, and student interactions in their courses, and student advising and mentoring. At the department, college, and institutional levels, the results can inform further data-driven exploration for modifying programs and policies. Faculty developers can use results to enhance or create new programs to support faculty in these practices or to inform a CTL's strategic plans [12, 13].

What issues would be appropriate for systems mapping? Issues with clear, limited, and well-defined interactions might not need an extensive systems mapping process to elucidate ideas. Systems mapping is beneficial when multiple stakeholders and perspectives are involved in the complex system, in which there are numerous factors and interdependencies. Examples in engineering education include undergraduate research, supplemental instruction and learning assistants, co-curricular activities, service-learning, and senior design, and scholarship of teaching and learning (SoTL). The framing of the guiding question for the systems mapping activity should be broad enough so that both personal experiences and perspectives, as well as observations, are welcomed. The general question, "what impacts [issue] in [context]?" can be a starting point. While the systems mapping activities described in the example were conducted in-person (before the Covid-19 pandemic), the process can be adapted to online environments using tools (such as Jamboard, Kumu, MURAL, InVision, and Stormboard) and videoconferencing platforms that provide small group interactions.

During the lightning talk, the audience will be invited to consider how systems thinking and systems mapping might be useful tools in their work and contexts to engage stakeholders and collect information, or for other purposes. The author invites conversations to share ideas and discuss questions about potential applications and implementation.

Acknowledgments

This project is supported by a Pott College Innovation seed award at the University of Southern Indiana (USI). This research is conducted under approved IRB #2019-192-SEE at USI. The author thanks Drs. Ronald Diersing, Jenna Kloosterman, and Paul Kuban for supporting this work by providing time to conduct the systems mapping activities during their classes.

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