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Student success and retention from the perspectives of engineering students and faculty

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Abstract

Student retention and success is a complex issue, with many factors that impact an individual student's retention and these factors varying across all of our students. At the University of Southern Indiana (USI), efforts within engineering, as well as across the college and university, have included intentional academic support services (such as expanded advising and tutoring services) and student development programs and extracurricular activities to foster student communities and a student's sense of belonging. In addition, evidence indicates that implementing curricular changes across an engineering program and within specific courses, such as implementing active learning, instructional innovations, and high-impact practices, can improve student success and retention.

This paper describes a systems thinking approach to gain better understanding of student retention and success from multiple perspectives. Through systems thinking, connections and interdependencies between elements related to the goal of improving student retention and success in engineering can be explored. Framing student retention in this connected and big picture perspective can help identify impacting factors that then inform potential solutions. The process involved engineering students, faculty, and staff in developing systems maps around the question "what impacts your (or students') success in engineering?" Systems mapping was used to collaboratively generate graphical representations of the many factors and actions that impact student retention and success and how they are connected through feedback loops and interdependencies. Systems mapping also creates opportunities for reflection of beliefs and assumptions around academic success and retention, interaction with other perspectives, and conversations. Students enrolled in Electric Circuits and Senior Design, which both are required undergraduate engineering courses, and engineering faculty and staff were invited to participate in the systems mapping activities. This paper discusses the results of the systems maps generated, with analysis of the overall set and comparison of the student- and faculty-developed systems maps.

Keywords: student retention, student success, systems thinking, student perspectives

Background

Student retention and success is a complex issue, with many factors that impact an individual student's retention and these factors varying across all of our students. Reports have highlighted the need to recruit, retain, and support degree completion of diverse student populations in STEM and put forth calls to action and the need to identify and address critical factors that impact student retention [1], [2], [3], [4], as well as clarifying and using indicators for monitoring [5], [6].

At the University of Southern Indiana (a public, comprehensive institution), efforts within engineering and across the university have included intentional academic support services (such as expanded advising and tutoring services) and student development programs and extracurricular activities to foster student communities and a student's sense of belonging. In addition, evidence indicates that implementing curricular changes across an engineering program and within specific courses, such as implementing active learning, instructional innovations, and high-impact practices, as well as can improve student success and retention [3], [7]. While institution-wide strategies, such as student support services, enhanced advising, and summer bridge programs, have improved student success, change regarding teaching practices and curriculum are needed at the department and faculty levels in conjunction with institutional efforts to further these improvements.

Incorporating students' perspectives sometimes can be limited in the development and implementation of initiatives intended to improve student retention and success. Studies that probe the perspectives of undergraduate engineering students primarily have focused on faculty teaching effectiveness [8], [9], specific instructional strategies [for example, 10], or curricular or co-curricular programs [11], [12]. Within engineering, student feedback on their broader experiences often is solicited during senior exit surveys, interviews, or focus groups as part of an engineering program's ABET assessment process.

The goal of the work described in this paper is to gain better understanding of student retention and success from multiple perspectives using a systems thinking approach. Through systems thinking, we can explore connections and interdependencies between elements related to the shared goal of improving student retention and success in engineering. Framing student retention in this connected and big picture perspective can help us to identify bottlenecks and pathways that then can inform potential solutions and opportunities. For faculty members, this perspective can help inform their course development, instructional practices and curriculum reform, as well as their advising and mentoring with students. For students, this reflection on their experiences promotes their metacognition on what they perceive are the supports and barriers to their academic success.

The research questions explored in this study are: 1) What do students and faculty identify as factors that impact student success and retention in engineering? 2) In what ways are students' and faculty's perspectives on student success similar and different? To address these questions, the objectives of this study are to: 1) collect students' and faculty members' perspectives on student success and retention in engineering via systems mapping, and 2) identify and compare the themes identified by the different groups. This study is part of a broader project to explore what impacts student retention in STEM in order to inform actions to address the identified issues and to engage faculty in student retention and success inquiries [13].

Methodology

In this study engineering students and faculty members were invited to collaboratively develop systems maps around the question "what impacts your success in engineering at USI?" (for students) or "what impacts student retention and success at USI?" (for faculty members). Systems mapping was selected as the tool for gathering information from student and faculty participants because the process can elicit more in-depth responses compared to most surveys and focus groups. In this study, participants were asked to participate in a systems mapping activity, which included individual and group components, to generate graphical representations of the many factors and actions that impact student retention and success and how these elements are connected (or not) through feedback loops and interdependencies. Systems mapping also creates opportunities for reflection of beliefs and assumptions around academic success and retention, to interact with other perspectives, and to start conversations [14].

Two required undergraduate courses across all engineering majors were selected to recruit student participants. One course was Electric Circuits, which has a total enrollment of 48 students in three course sections, with 27.1% sophomores, 50.0% juniors, and 22.9% seniors, based on credit hours completed. This course was selected because the students have progressed through most of the foundational engineering curriculum (e.g., calculus, physics, statics). The second course was Senior Design/Project, with 29 senior students enrolled. This course was selected as a way to capture the experiences of students who were near the completion of the engineering program (most of whom were in their final semester). The systems mapping activities with the students were coordinated with the faculty members who instructed these courses and conducted during the sixth week of the semester, after students have become familiar with the course, semester routines, and their class members. Faculty participants were recruited during a Department of Engineering meeting in coordination with the chair. Student and faculty participation were voluntary in all of the activities.

The systems mapping activities were facilitated by the investigator/author, who is an engineering faculty member who also serves as a faculty developer in the institution's teaching and learning center. As a faculty developer, this individual might be viewed having an objective and broad perspective, with awareness of activities and interactions with members across the institution. In addition, the faculty developer role equips this individual with effective facilitation strategies and expertise in teaching and learning, including engineering education. The systems mapping activity has been used in similar undergraduate student retention and faculty development contexts by the investigator [15].

In each class or meeting, groups of 3-5 participants were randomly formed. Depending on the number of participants in the session, there were 3-6 groups in each session. Participants were informed that the terms "student success" and "student retention" were broadly defined (i.e., beyond the course and curriculum) and interpreted in their individual contexts during the systems mapping activity. They also were informed that there were no right or wrong responses and the purpose of the activity was to seek their input based on their experiences. The systems mapping activity required 30-40 minutes to complete in each session. The following procedure was used to guide the participants in developing the systems maps and was facilitated by the investigator:

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

1. Take a few minutes to individually identify: What enables and inhibits your (or students') success in engineering at USI? Write one element per sticky note. Use as many sticky notes as you need.
2. Please post your notes to the easel pad on the desk. Take a few minutes to silently read what others in your group have written.
3. Now work with your group to form clusters of enablers and inhibitors by moving the sticky notes.
4. Label each of the clusters. More sticky notes may be added.
5. How might individual elements and clusters connect to each other? Draw arrows to show these connections and interdependencies.
6. What are the three most important factors? Mark them with a star.

The systems maps generated in each session were analyzed and compared. A thematic analysis of the systems maps was conducted [16], using the identified clusters and looking for emerging themes in each systems map from individual sticky notes (elements) and the clusters. The overall systems maps and the content and structure contained within were compared to glean similarities and differences between the three participant groups: students in the Electric Circuits course, students in Senior Design, and engineering faculty and staff members. In particular, the analysis included themes from the clusters and elements, the quantities and types of elements (e.g., structural, attitudinal, or relational), and whether participants viewed the elements as enablers or inhibitors [17]. The process allowed for emergent themes, based on the identified clusters and elements. Finally, the identified connections between clusters and elements were compared across the sample systems maps.

To contextualize the student-generated systems maps, student background data are summarized in Table 1, with aggregate information on the students' GPA, transfer student status, and gender.

Table 1. Summary of student participants groups.

Course	n	GPA avg (stdev)	Transfer	Male	Female
Electric Circuits	48	3.20 (0.52)	12.5%	83.3%	16.7%
Senior Design	26	3.10 (0.49)	30.8%	92.3%	7.7%

Results and Discussion

This section discusses and compares the systems maps generated by the engineering students and faculty and suggests opportunities to improve student success. The participating engineering students and faculty generated 21 systems maps with a total of 442 elements (sticky note entries) and 48 clusters identified (Table 2). In all of the elements and clusters in the student- and faculty-generated systems maps, participants identified 307 elements (69.5%) as enabling and 154 (34.8%) elements as inhibiting student success, with some elements labeled as both enabling and inhibiting. A similar distribution exists for the factors (elements or clusters) that participants identified at most important, with 106 enabling elements (69.3%) and 52 (34.0%) inhibiting elements. Since participants did not identify all of the elements as enable or inhibit, this classification was inferred during analysis for some elements.

Table 2. Summary of all systems maps across the engineering students and faculty groups.

Group	**n**	**# systems maps**	**# clusters**	**# elements**	**# enabler elements**	**# inhibiting elements**
Electric Circuits	48	12	25	229	155	81
Senior Design	26	6	22	123	75	49
Engineering faculty & staff	16	3	14	90	77	24
Total	90	21	48	442	307	154

In a separate analysis, the participant-identified elements were classified as structural, attitudinal, or relational types of factors that impact student success. Structural factors are the practices and resources of the institution or environment, attitudinal factors are based on values, beliefs, and attitudes, and relational factors involve interactions between students, faculty, and/or family. The factors that participants identified as most important in impacting student success (step 6 of the activity) were classified into these three types, and nearly equal number are structural or attitudinal (approximately 40% for each type) and half as many are relational (Table 3). Among these, common structural factors are instructional practices and student learning experiences, faculty effectiveness, and students' job commitments; attitudinal factors include students' work ethic and motivation and faculty interest in students and the subject; and relational factors include students' peers as study partners and friends, faculty-student interactions, and faculty approachability. With over 60% of the factors classified as either attitudinal and relational, the individual (i.e., the faculty member or student) can control these factors to an extent; however, changing the habits and interactions of individuals and groups can be challenging that requires intentional and sustained efforts. At the same time, faculty members and departments also contribute to some structural factors such as instructional practices and curriculum.

Thematic analysis of the factors that participants identified as most important resulted from the clusters in the systems maps and emergent themes. These themes, from least to most frequent mentioned, are institutional resources (e.g., student opportunities and support services), community (e.g., students' peers and family), courses/curriculum (e.g., instructional practices and course options), students (e.g., intrapersonal attributes and background), time management, and faculty (e.g., teaching effectiveness and interactions) (Table 3). The student-focused themes of community, time management, and student personal attributes comprise over 50% of these important factors, while faculty-related themes of courses/curriculum and faculty are nearly 45% of the identified important factors aggregated from the three groups.

Table 3. Summary of factors that students and faculty identified as most important in impacting student success, by factor type and theme.

Factor Type	Count (%)
Structural	60 (38.2%)
Attitudinal	67 (42.7%)
Relational	30 (19.1%)

Theme	Count (%)
Institutional resources	7 (4.6%)
Community	13 (8.5%)
Courses/curriculum	14 (9.2%)
Time management	25 (16.3%)
Students	42 (27.5%)
Faculty	52 (34.0%)

Comparing the most important factors identified in the systems maps across the three groups, student personal attributes, faculty, and courses were common themes. The systems maps developed by students in Electric Circuits identified themes of faculty effectiveness, course structure, and experiences (curricular, co-curricular, and external), time management and schedule, resources and facilities, and personal factors. These systems maps included more connections between clusters and elements and additional notations compared with the systems maps in the Senior Design and faculty/staff groups. The Senior Design systems maps identified student-focused (including interpersonal and intrapersonal), faculty-related, and course-related factors, along with time management and institutional resources. The faculty-developed systems maps emphasized students' work ethic, time management, and mindset, along with faculty's teaching skills in motivating, engaging, and interacting with students. While these themes were not surprising, the specific factors within these themes demonstrate self-reflection and awareness of the students in identifying what they perceive as factors impacting their success and the relationship between these factors, and offer suggestions for faculty and the institution.

Figures 1-3 show sample systems maps from each of the three groups. Due to the open and flexible system mapping process used, these samples show the variety of systems maps, rather than being representative; nevertheless, the clusters and elements reflect common factors. In the sample Electric Circuits systems map (Figure 1), students identified "mostly having a class that interests me," "wanting to be successful in life," and "my own work ethic" as important factors to their success. In the sample Senior Design systems map (Figure 2), important factors that the students identified include "the willingness of the engineering faculty to work with me at any time," "engaging & knowledgeable professors," "time - increased time on something increases success," and "joining clubs & organizations." In the sample systems map developed by engineering faculty and staff (Figure 3), important factors include "faculty [teaching] load," "Does the professor make the class interesting & relevant?", "student work ethic," "time management," and "[student's] course schedule."

Concluding Remarks

The results of the systems mapping activities with engineering students and faculty provided a different way of gathering perspectives on student success in the engineering program. The systems mapping activity asked participants to take a broader, systems view while still including opportunities for more granular items concerning curriculum, instruction, and student challenges. Moreover, because the process includes both individual reflection and collaborative tasks, the systems mapping activity provides opportunities for the input of all participants' voices while also benefitting from conversations and analysis within small groups. Through this experience, the generated systems maps and results of this study complement the information gathered through existing ABET outcomes assessment and program continuous improvement processes. The engineering department plans to incorporate the results of the systems mapping activity in its on-going use in program assessment cycles.

There is a potential role for enhanced faculty development in response to the results from the systems maps. Calls to improve student retention and success have become more frequent and urgent, often stemming from pragmatic issues such as student population shifts and state funding models. This provides opportunities for faculty development and collaborations with teaching and learning centers to identify and develop improvements that address student retention goals. This can be synergistic since a focus of teaching and learning centers is increasing the implementation of evidence-based teaching practices, which contributes to improving student retention [18], [19], [20], as well as evaluating its impacts on student success [21].

During the presentation, the audience is invited to the conversation. Guiding questions include: How do these systems maps compare to your mental model of student success? What surprised you or caught your attention? How might systems mapping be used in your contexts?

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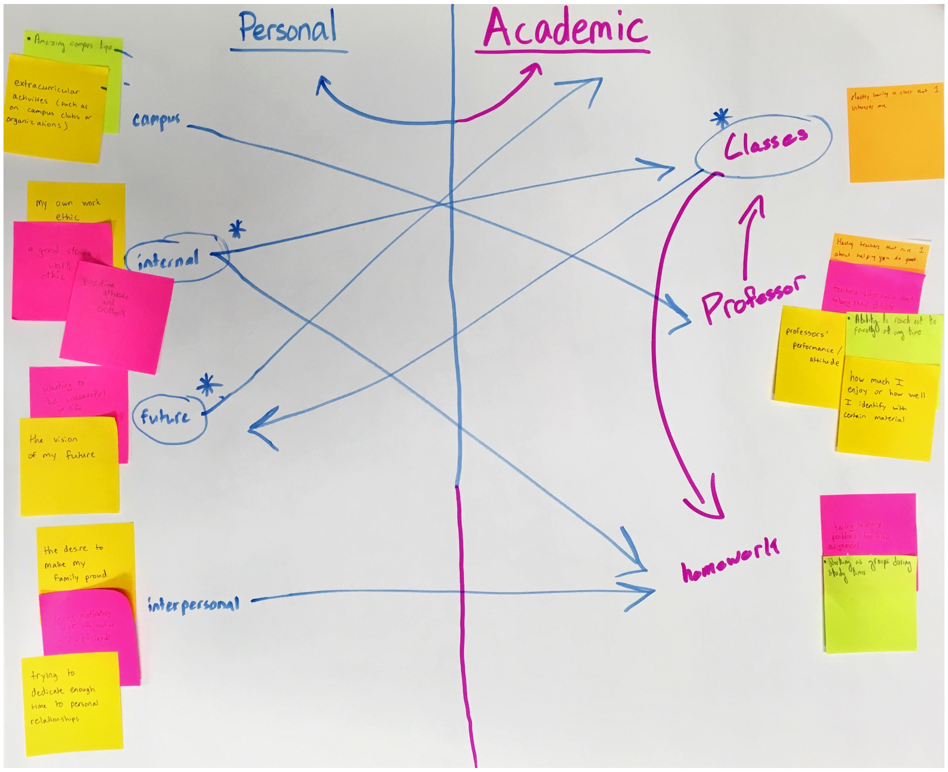

Figure 1. Sample systems map developed by students in the Electric Circuits course.

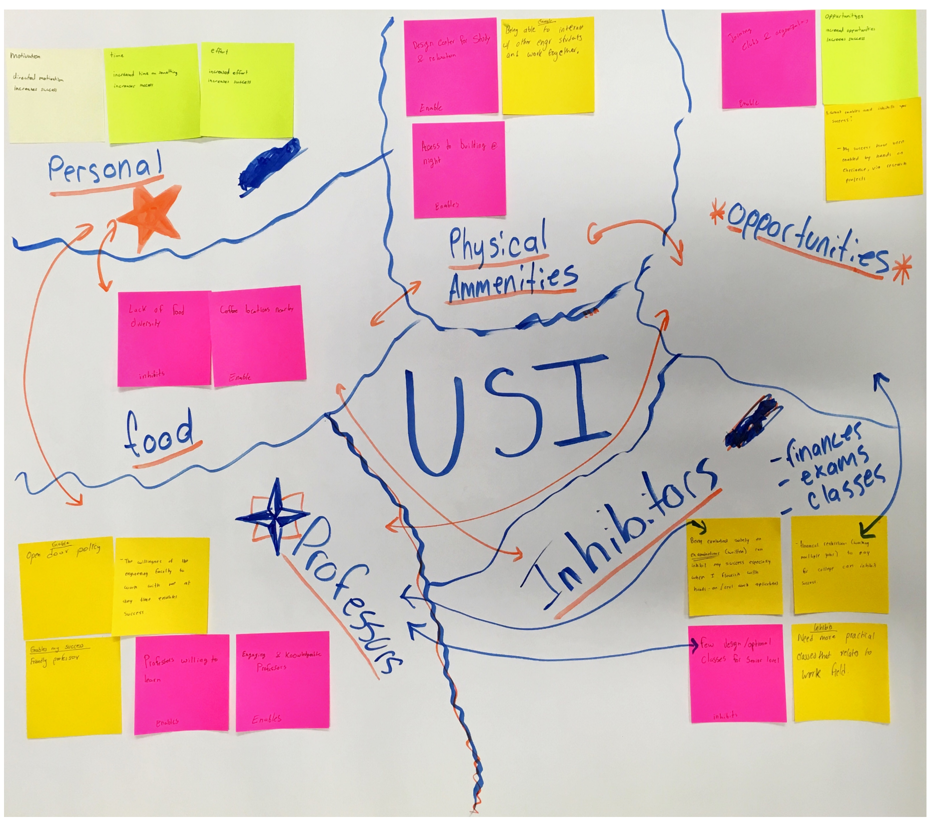

Figure 2. Sample systems map developed by students in the Senior Design course.

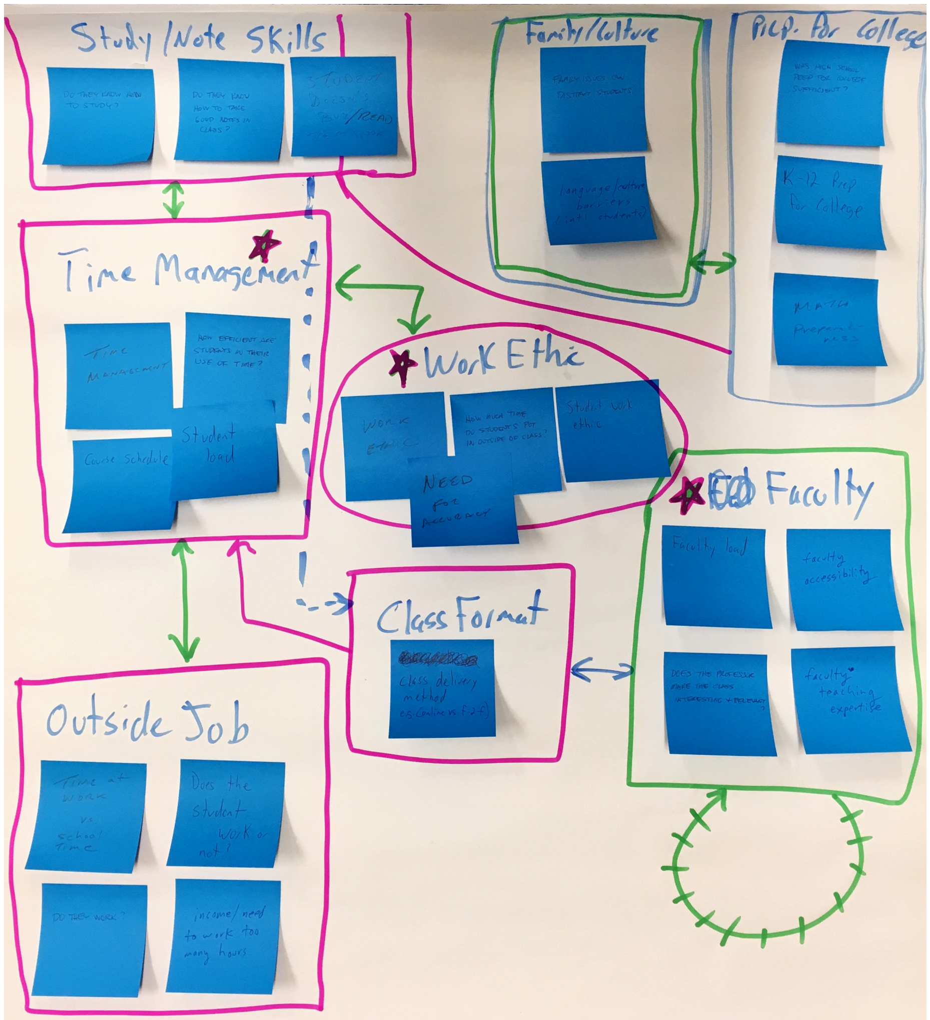

Figure 3. Sample systems map developed by engineering faculty.

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