Student Success – Oriented Needs Analysis: A Conceptual Framework

Tracee Walker Gilbert[1], Janis P. Terpenny[2], Sharnnia Artis[3]

Abstract - Student success research in higher education has provided an immense understanding of those factors that explain why students decide to leave, and to some extent, why students persist on to graduation. However, few studies have leveraged student success research to identify an inventory of needs that should be met in order for students to succeed in college. This paper leverages a collection of influential student success theoretical perspectives to develop a needs analysis framework to elicit and identify engineering student success needs. The conceptual framework provides a structured participatory method to translate vague student needs into actionable statements that holistically capture the needs of engineering students. Lastly, this paper outlines the importance of incorporating this framework into the development process for constructing an Engineering Student Needs (ESN) questionnaire.

Keywords: Student Needs, Student Success, Needs Analysis

MOTIVATION

For over 70 years, researchers have been attempting to unravel the complexities associated with enhancing student retention and success in higher education[1]. It is estimated that less than half of the students who initially major in an engineering discipline go on to earn their bachelor's degree within five years. Moreover, underrepresented minorities (i.e., African Americans, Hispanics, and Native Americans) drop out at even higher rates than their majority peers[2]. Student success research has resulted in a better understanding of why some students decide to leave and to some extent why students decide to persist on to graduation. However, little work has been devoted to translating the various theoretical findings into specific strategies that will guide institutions in improving student success outcomes[3, 4].

This research is a part of a larger research effort to develop a Student Success-Oriented System Design (S^2OSD pronounced "*SAWS-D*") methodology. This effort will integrate a collection of student success theoretical perspectives with a growing body of knowledge on customer-oriented systems approaches in order to address the following pressing need: How can institutional leaders in higher education translate the needs of their students into actionable solutions that will facilitate student success? In order to provide a concrete course of action for institutional leaders to design practices that meaningfully facilitate student success, institutional leaders must first have an understanding of the needs of their students. Therefore, this paper presents a conceptual framework that describes the development of the Student Success-Oriented Needs Analysis (S^2ONA pronounced "*SAWNA*") framework. The purpose of the S^2ONA framework is to provide the method and tools to:

- Comprehensively identify and document engineering student needs.
- Provide a guiding theoretical framework for justifying relevant student needs[5].
- Elicit latent or hidden needs as well as explicit needs directly from students[5].
- Ensure that critical needs are not missed or overlooked[5].
- Provide the foundation for the S^2OSD methodology, which will ensure that student needs are the driving force behind the design of student success practices.

[1] Virginia Polytechnic Institute and State University's Department of Industrial & Systems Engineering (ISE), Blacksburg, VA 24060, trwalker@vt.edu

[2] Virginia Polytechnic Institute and State University's Departments of Mechanical, Engineering Education, and ISE, Blacksburg, VA 24060, terpenny@vt.edu

[3] Ohio State University, College of Engineering, Columbus, Ohio 43210, Sharnnia_Artis@engadmin.ohio-state.edu

STUDENT SUCCESS THEORETICAL PERSPECTIVES

The S^{2}ONA framework (within the S^{2}OSD methodology) is motivated by a collection of influential student success theoretical perspectives, in which the most frequently cited theories define student success in college in terms of persistence, educational attainment, and obtaining a degree[6]. Although several theories have been developed, a summary of the most comprehensive and influential theoretical models are presented in Table 1 to provide an understanding of those factors associated with student success.

Table 1: Relevant Student Success Theoretical Perspectives

Perspective	Theoretical Perspective	Purpose
The Sociological Perspective	Student Integration Model[7]	Students' decisions to persist or to drop out are based on their integration into the formal and informal academic and social systems of the institution.
The Organizational Perspective	Student Attrition Model[8]	Concentrates on the impact that the institution (i.e., organization) has on the socialization and satisfaction of students.
The Psychological Perspective	Student Attrition Model[9]	Focuses on the role of psychological characteristics that distinguish between those students who persist and those who drop out.
The Financial Perspective	Financial Nexus Model[10]	Highlights the role that finances play in persistence decisions.
The Minority Perspective	Student/Institution Engagement Model[11]	Emphasizes the unique challenges that diminish the quality of the minority student college experience.
The Involvement /Engagement Perspective	Theory of Involvement[12], Student Engagement[13]	Focuses on the behaviors that students engage in and the institutional conditions that are related to student success.

In reviewing the wide array of student success research literature, consistent patterns have emerged from across the various theoretical perspectives. First, each of the theoretical perspectives (with the exception of the involvement/engagement perspective) in Table 1 focuses on attrition and persistence. Even though these perspectives have provided an immense understanding of the factors that impact college attrition and persistence, these theories do not focus on understanding student needs in the context of student success theoretical perspectives.

Secondly, these theoretical perspectives emphasize that both student characteristics/behaviors and institutional conditions impact student success. Student behaviors include involvement in extracurricular activities, interaction with faculty and peers, motivation, and commitment. Institutional conditions include the resources and educational practices that facilitate positive student behavior[6]. Since institutions vary considerably in their size, culture, and student demographics, a framework is needed that would allow institutions to tailor their practices to fit the unique needs of students within their campus environment[1].

Thirdly, these models have traditionally served as the foundation for both the student success research studies. However, engineering education is considered uniquely different from other majors [14, 15]. To begin with, the engineering curriculum requires problem solving and analytical skills that are shaped by a fast paced and demanding course load, heavily grounded in science and math [15, 16]. Furthermore, the engineering college culture is typically described as a white male-dominated, competitive environment that features rigid discipline, intense academic pressure, and weeding-out practices that begin early in the introductory courses [17, 18, 19, 20]. Due to the unique character of engineering education, the general education student success theories (Table 1), which are typically used as the foundation for engineering student success research as well, do not adequately address engineering student success[15].

Lastly, a multitude of variables from each of the student success theoretical perspectives are summarized in Table 2 to guide our understanding of those factors that are critical to student success. The columns summarize the variables from each of the theoretical perspectives described in (Table 1). These variables are categorized in the table's rows based on the student success literature as follows: pre-entry, academic, psychological, social, financial,

and environmental. This categorization will help to provide the content domain and theoretical boundaries for the S2ONA framework, thus enabling us to focus on identifying specific student needs that are relevant and critical to student success. For example, even though institutions offer a number of services to facilitate the college experience, such as food and recreation services, they do not fit into the context of student success theoretical perspectives.

NEEDS IDENTIFICATION AND ANALYSIS

While higher education research has focused on success from a student orientation, there is also a large body of research that is devoted to understanding and satisfying customer needs as the means for achieving success. From a marketing perspective, organizations adopt a customer orientation to obtain and use information from customers, develop strategies to meet customer needs, and implement those strategies by being responsive to customers' needs. Similarly, a quality management approach adopts a customer orientation (i.e., customer focus) that requires the entire organization to be focused on providing products and services that fulfill customer needs[21]. Lastly, systems engineering provides an interdisciplinary process to transform customer needs into system solutions[22, 23] that optimally satisfies their need. Central to each of these approaches is the underlying assumption that the customer's needs form the basis from which success is realized.

This paper will adopt a systems approach, which typically begins with defining needs (i.e., the problem) in terms of requirements. The S^2ONA framework is focused on the needs definition process, which is referred to as a needs analysis, in order to understand the true needs of the customer[25]. This requires the translation of the voice of the 'customer' into specific requirements[23].

A requirement represents a customer's need in a statement that can then be used to derive solutions that address those needs[26]. Requirements are typically expressed in functional terms, in which a "function is defined as a specific or discrete action that is necessary to achieve a given objective[27]" (pg.62). By specifying 'what' actions a system must perform before considering 'how' the system will actually perform those functions (i.e., what is needed to be accomplished versus how it should be done) ensures the consideration of the broadest possible set of feasible designs without being limited to fixed or conventional solutions [23, 26, 28, 29].

Even though the systems approach has traditionally focused on customers (also referred to as users, consumers), its fundamental premise offers promising insights for understanding and designing a system of practices that meet the needs of engineering students. Just as technical systems perform specific functions, institutional practices are designed to fulfill specific actions and activities required to facilitate student success. Therefore, 'requirement-like' statements will be developed to precisely capture the fundamental actions of institutional practices that facilitate student success. These actionable need statements will subsequently be used to derive solutions (in a later phase of the S^2OSD methodology) that address those needs. Since needs are often unwittingly or not clearly articulated by customers[30], an abstraction process will be undertaken to make it possible to define student needs in such a way that captures critical needs in the context of the student success theoretical perspectives.

While it is noted that students are being educated because they have not formed the requisite skills to judge or know what they need[31] in certain aspects of educational process[32] (e.g., curriculum development), this paper adopts the 'student as a customer' metaphor. As Astin[33] pointed out, the richest source of data on the students' college experiences is the students themselves. They are the primary recipients of higher education[31], and will serve as a vital resource in identifying their needs.

S^2OPD METHOD

The S^2ONA will utilize the S^2OPD (Student Success-Oriented Participatory Design) method described in this section to elicit and identify engineering student needs in the context of student success theoretical perspectives. Central to this approach is a participatory and customer-centered design philosophy[34, 35] that institutional decision makers (i.e., administrators, faculty) are not the only experts when it comes to defining student needs and developing student success strategies to meet their needs. In this approach, students play a vital role in identifying and eventually developing strategies that address their own needs.

The structure of the S^2OPD method will follow the five- step process illustrated in Figure 1 to facilitate a team meeting in order to identify and translate the of the voice of the 'student' into requirements. These actionable need statements will be used as the basis for developing an ESN questionnaire.

Table 2: Student Success Factors

Factors	Sociological	Organizational	Psychological	Financial	Minority	Involvement	Engagement
Pre-Entry	Family Background	Performance	Past Behavior	Student Background	Pre College Ability	N/A	N/A
	Skills and Abilities	Socioeconomic Status	Personality	College Choice Fixed Costs	Psychsocial Factors		
	Departure Decision	State Resident	Self Efficacy and Attribution	College Choice	Financial Assistance/Need		
		Distance Home	Normative Beliefs	Controllable Costs	Encouragement/Family Support		
		Hometown Size	Coping Strategies		Environmental Pull Factors		
			Motivation to Attend				
			Skills & Abilities				
Academic	Academic Performance	University GPA	Academic Integration	Grades	Involvement in Learning Communities	Time/Energy Studying	Level of Academic Challenge
	Academic Integration		Academic Performance		Academic Performance	Time on Campus	Active and Collaborative Learning
			Academic Interactions		Academic and Intellectual Development	Student Organizations	Experiences
Financial	N/A	N/A	N/A	Financial Costs	N/A		
Social	Extracurricular Activities	Integration	Social Interactions	N/A	Social Experiences	Faculty Interaction	Student-Faculty Interaction
	Peer Group Interactions	Advisor	Social Integration		Faculty Interactions	Student Interaction	
	Faculty/Staff Interactions	Staff/Faculty Relationship			Validating Experiences		
	Social Integration	Campus Organizations			Mentoring Experiences		
Psychological	Institutional Fit	Goal Commitment	Self Efficacy	Aspirations	Noncognitive Gains	N/A	N/A
	Institutional Commitment	Major (certainty)	Coping (Approach/Avoidance)		Educational Aspirations		
			Attributions		Educational Goal		
			Intentions		Institutional Commitment		
			Goal Commitments				
			Institutional Commitments				
			External Commitments				
Environmental	N/A	Routinization	Bureaucratic Interactions	College Experience	Campus Climate	N/A	Supportive Campus Environment
		Development	External Interactions				
		Practical Value					
		Institutional Quality					
		Communication					
		Development					
		Centralization					
		Campus Job					
		Major (area)					
		Housing					
		Opportunity					
Outcomes	Departure Decision	Institutional Satisfaction	Intent to Persist	Probability of Persistence	Re-enrollment	N/A	N/A
		Institutional Commitment	Persistence Behavior				
		Dropout					

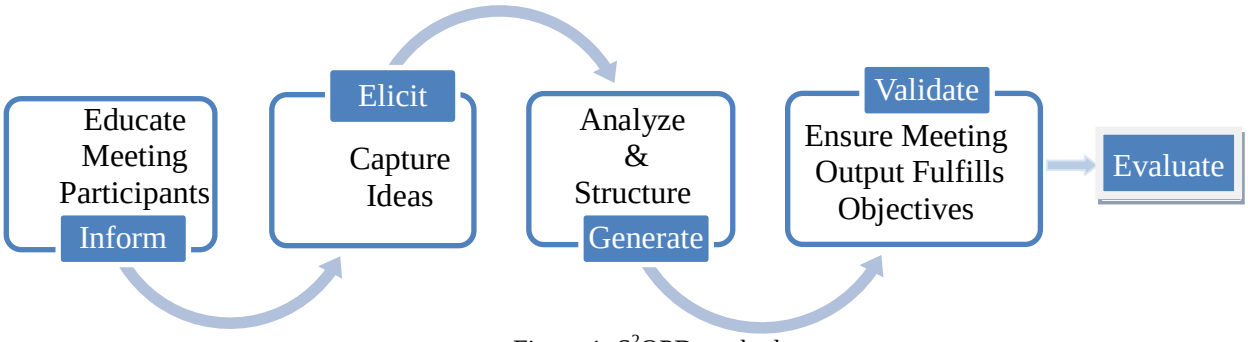

Figure 1: S[2]OPD method

As illustrated in Figure 1, the *Inform* step educates participants about the goals of the meeting, the procedures, and key outputs to inform participants of their roles and responsibilities during the meeting. During the *Elicit* step, the researcher obtains information to help determine the perceptions and ideas of the group based on the scope of the meeting. The *Generate* step then uses system design and quality management tools to organize the initial brainstorming ideas (resulting from the Elicit Step) into a structured format. Finally, the group will ensure that the final output addresses meeting objectives during the *Validate* step. At the conclusion the meeting, participants will then be asked to *Evaluate* the usefulness of the framework. Table 3 summarizes key aspects of the S[2]OPD method, which have been adapted from commonly used qualitative and participatory design methods.

Table 3: Key Concepts of the S[2]OPD Method

Concept	Adapted	Benefits
Involves 4-6 participants	Focus Groups[36]	Although traditional focus groups are larger[37, 38], smaller groups are preferred for design research sessions[36].
Involves 3 -5 group sessions	Focus Groups [37]	More groups seldom provide meaningful new insights[37].
2 hour sessions	Focus Groups[38]	Covers the needed information without exhausting the participants[43].
Team approach is guided by a facilitator (e.g., leads a group discussion following independent individual level work)	Focus Groups[38], Nominal Group Technique[39] Participatory Design[40]	Group perspective can lend additional insight that could not otherwise be gained from an individual level of analysis [44].
Focused discussion guided by predetermined questions in which the facilitator also asks probing and clarifying questions	Focus Group[38]	Obtains in-depth rich information that is guided by student success theoretical perspectives.
Meeting participants work independently and silently to generate and record ideas. They then share their ideas in a round robin fashion.	Nominal Group Technique[39]	Minimizes pervasive influences by other group members[45].
Empowers students to be actively engaged in identifying and analyzing their needs.	Participatory Design[40]	Unlike any of the preceding techniques, participatory design requires participants to identify significant patterns and organize resulting data. Thus, the team will participate in the data analysis *during* the S[2]OPD meeting.
Determines the needs of students.	Requirements Elicitation [41, 42]	Improvements can be made with a higher probability of satisfying student needs[41].

S²ONA FRAMEWORK

The S²ONA framework provides a guide to understanding the needs of engineering students. The purpose of this framework is to translate the voice of the 'student', often expressed as vague ideas in their own words, into functionally precise statements. These actionable need statements (i.e., requirements) will holistically capture the needs of engineering students within the context of student success theoretical perspectives. The S²ONA framework will follow the five step process illustrated in Figure 1.

Step 1: Inform

Participants will be asked to share their experiences in a group discussion that is guided by a facilitator with no more than 6 participants over the course of a 2-hour period. The following goals have been established for this meeting. Additionally, objectives have also been established to ensure that this study is focused on identifying student needs in the context of student success theoretical perspectives. These objectives will also provide participants a reference point for determining whether their input falls within the scope of this research.

- ***Goal #1: Identify enablers and hinderers of engineering student success.*** Identifies enablers or causes that lead to student success, and hinderers or barriers that impede student success.
    - ***Objective #1: Define critical factors in the context of student success***. Identifies those factors that will lead to the retention, graduation, and academic achievement in the engineering program.
    - ***Objective #2: Include only post-enrollment factors***. Identifies only those factors that the institution can directly impact (e.g., "improving high school math instruction" could not be included because this is outside the scope of the institution's influence).
- ***Goal #2: Translate enablers/hinderers into student need statements.*** Defines functionally precise need statements.
    - ***Objective #3: Generate actionable need statements***. Defines functionally precise need statements that provide a specific or discrete action that must be performed by institutional practices.
- ***Goal #3: Provide a comprehensive set of student needs.*** Organizes the student need factors (i.e., categories), and groups them with their associated need statements to provide a comprehensive set of student needs.

To achieve these goals, Figure 2 summarizes the mapping process that is embedded in the S²ONA framework to execute each part of this meeting, which describes the process of translating the voice of the 'student' into a comprehensive set of student needs that will facilitate student success. A color coding scheme will be used in the remaining steps to track key aspects of this process as follows:

- Blue – Enablers
- Pink – Hinderers
- Yellow – Student Need Statements
- Green – Student Need Categories
- White – Pre-defined Student Need Categories (based on the Student Success theoretical perspectives)

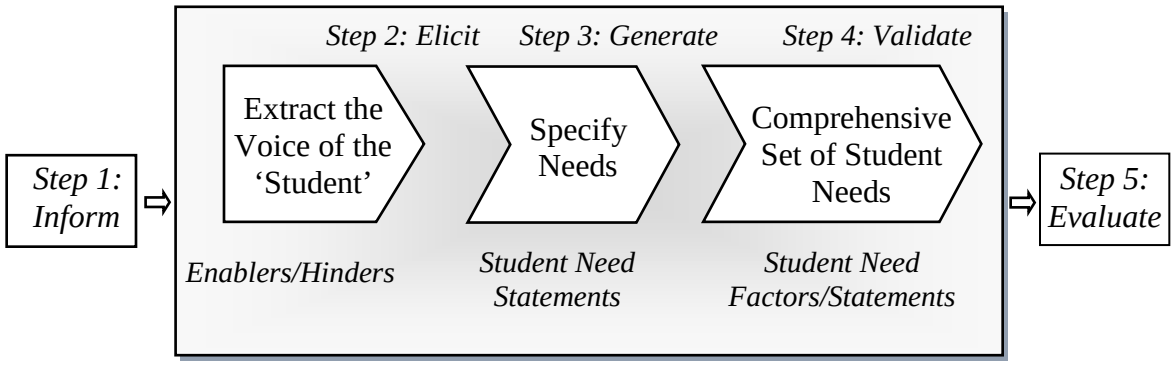

Figure 2: S²ONA Mapping Process

Step 2: Elicit

Once participants have an understanding of the scope of the meeting, they will then be guided through a brainstorming exercise by the facilitator. The first set of questions allows the group to reflect on their own experiences and provide their perception of those needs that facilitate engineering student success.

Discussion Question #1: If you had to create a report card that measured engineering "student success needs," what would be the major categories? (Each category will be written on a separate green Post-it note).

This discussion question allows participants to identify their perception of those broad student need factors that are required to facilitate their success without being biased by input from other participants or the facilitator. These green Post-It notes will be revisited during Step 3.

Discussion Question #2: What characteristics of your engineering experience have enabled and/or hindered your success? (Each *enabler* will be written on a blue Post-it note and each *hinderer* on a pink Post-it note)

The starting point for the brainstorming exercise will be pre-defined student need factors (Table 2) that were identified from the student success theoretical perspectives: academic, social, psychological, environmental, and financial needs. Pre-entry factors are outside the scope of this meeting because the focus is on post-enrollment factors, as described in objective #2. The meeting participants will be asked to write down their ideas on a piece of paper (Figure 3). On the left side of the paper, participants will be instructed to affix the blue Post-it notes that describe characteristics of their engineering experience that has enabled (or caused) their success. On the right side, participants will be instructed to affix pink Post-it notes that have hindered their success. Following this exercise, the participants will be instructed to group similar enablers/hinderers. Then, in a round-robin fashion, each participant will be asked to share their ideas by putting their self-adhesive Post-It notes onto the walls of the conference room, and discussing their input with the group.

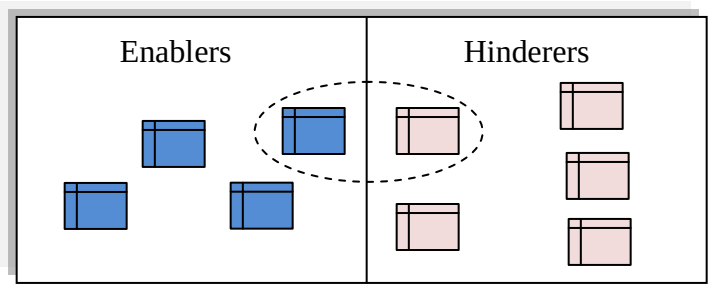

Figure 3: Example Problem - Buying/Cooking Healthy Food: Identifying Enablers and Hinderers

Discussion Question #3: What needs must be fulfilled in order to facilitate the success of engineering students.

(Each need statement will be written on a separate yellow Post-It note)

The purpose of this question is to transform the enablers and hinders into actionable need statements using yellow Post-It notes. This requires the group to write functionally-precise statements that describe what actions are needed to facilitate student success. If possible, the statement should include an action verb followed by a noun. To ensure that participants understand this exercise, the group will first will walk through one "need category, and then they will be divided into teams of two to complete this exercise for an assigned need category(ies). Subsequently, each group will present their functionally precise need statements and the group as a whole will comment and edit the need statements as necessary.

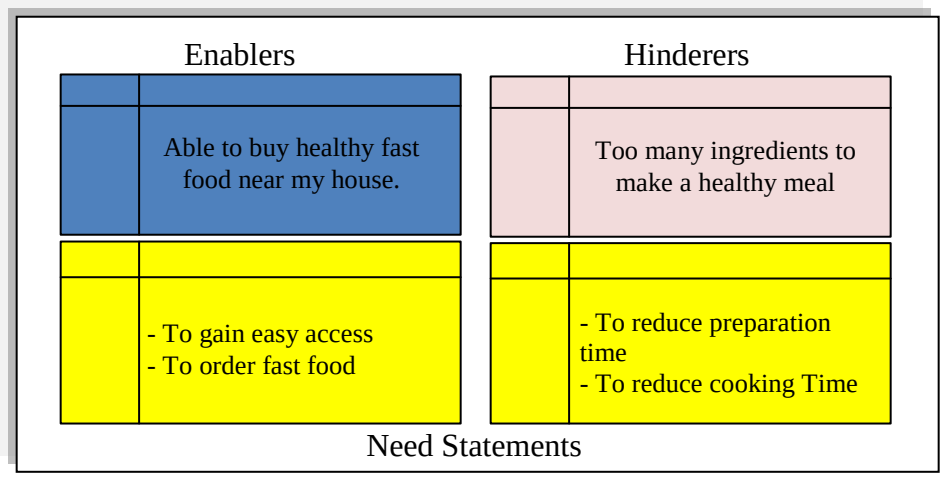

Figure 4: Example Problem – Translating 'Voice of the Student'
Into Actionable Need Statements

Step 3: Generate

The third step in the process will require the team to analyze and structure the need statements into a hierarchical structure using the affinity method. This method is a brainstorming technique for generating ideas in a group setting, which is used to analyze and organize ideas based on their natural relationships[42].

The group will graphically organize the student need statements based on the initial pre-defined student need factors or categories (white Post-It notes). The associated student need statements (yellow Post-it notes) will then be connected with lines to generate the affinity diagram in the form of a tree (Figure 5). During this part of the meeting, participants will be asked to share their responses to Question #1. The green Post-It notes will then be affixed to the wall model. Categories may emerge that require the design team to repeat these design steps.

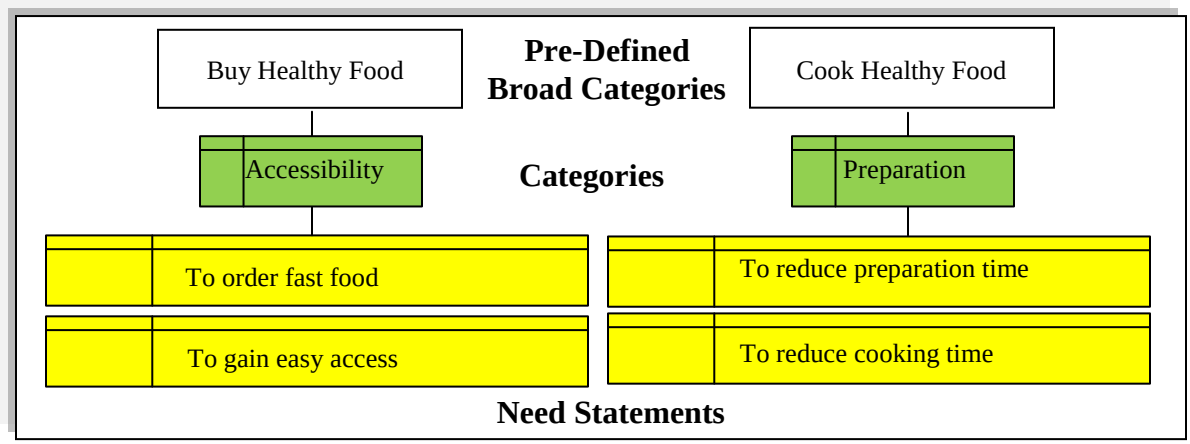

Figure 5: Example Problem – Affinity Model

Step 4: Validate

The final step of the meeting will allow the group to determine whether the output satisfies the meeting's goals. First, the group will review the meeting's goals to ensure that they have been met. Then, the team will review the final affinity model to ensure that there is agreement amongst the group with respect to its ability to meet the stated goals. If open issues still remain, the group will iterate through the meeting process to elicit, generate, and validate the output.

Discussion Question #4: Are all of the need statements critical to student success?
Discussion Question #5: Do you have additional input that needs to be added to make the affinity model complete?

Step 5: Evaluate

A formative evaluation will be performed to collect feedback from the users of the S^{2}ONA framework in order to evaluate the usefulness of the approach. A performance-based approach to evaluation will be used to collect quantifiable information that will help determine if S^{2}ONA framework actually meets the goals it sets out to achieve. Performance-based evaluations are useful in clarifying the efficacy of the process. As shown in Table 4, a 5-point performance-based Likert scale will be administered to evaluate the quality outputs from the S^{2}ONA framework[46, 47].

Table 4: S^{2}ONA Evaluation

	Please answer the following questions.	1 = Strongly Disagree	2	3	4	5 = Strongly Agree
Design Goals	This meeting was able to draw out needs that I may not have considered at the start of the meeting.	❍	❍	❍	❍	❍
	This meeting was able to transform my needs from my initial broad ideas into functionally precise statements.	❍	❍	❍	❍	❍
	This meeting was able to comprehensively define the needs of engineering students that facilitate their success.	❍	❍	❍	❍	❍
Ease of Learning	I did not encounter problems in learning this process.	❍	❍	❍	❍	❍
	My peers could learn how to use this process.	❍	❍	❍	❍	❍
	My role in this in this process was clear and understandable.	❍	❍	❍	❍	❍
Ease of Participation	My participation in this process was straightforward.	❍	❍	❍	❍	❍
	My peers could participate in this process with ease.	❍	❍	❍	❍	❍
	I did not encounter problems participating in the process.	❍	❍	❍	❍	❍
Usefulness	I would recommend this approach to faculty and program administrators.	❍	❍	❍	❍	❍
	The information produced from this meeting can be used to understand the needs of engineering students.	❍	❍	❍	❍	❍
What aspects of the meeting were effective?						
If you encountered any problems, please explain?						
What needs to be improved?						

RELEVANCE TO QUESTIONNAIRE DEVELOPMENT PROCESS

The S^{2}ONA framework will serve as the foundation for developing an engineering student needs (ESN) questionnaire. Churchhill[48] developed a widely accepted process for developing and validating a questionnaire. The development process consists of defining the questionnaire items through specifying the domain of constructs and generating a sample of items. The remaining eight steps are concerned with collecting data and validating the instrument.

The specification of the domain of construct begins with a well grounded theory based on a thorough literature review. The literature review serves two purposes in the questionnaire development process. First, it provides the researcher with an understanding of previous attempts to conceptualize the construct under study. As

illustrated in Table 1 and Table 2, the review presented in this paper provided the student success conceptualizations, its boundary, and content domain. Secondly, the literature review reveals the need for a new measure. The review of the student success theoretical perspectives revealed that an immense understanding of those factors that impact college attrition and persistence have been identified, but the theoretical perspectives have not focused on understanding student needs in the context of student success theoretical perspectives. This research shifts the focus from trying to understand why students leave/stay to examining how to satisfy student needs, which requires the development of a new measure[49].

Once the domain of construct has been specified in the questionnaire development process, then the sample of items are generated to address the content's domain. In general, a pool of items are generated from the extant literature or developed by the researcher[49]. In this paper, a participatory approach has been presented that incorporates the voice of the student in the needs analysis process. By incorporating the voice of the student ensures that improvement strategies can be generated with a higher probability of satisfying student needs[41].

A second consideration in generating a sample of items requires the consideration of how the items will be written. Netemyer[49] provides simple rules of thumbs, which have also been incorporated into the Needs Analysis Framework, which include wording clarity, wording redundancy, and positively and negatively worded items. This paper presented an additional consideration in which actionable need statements were generated in order to provide the basis for developing student success practices that address student needs.

Finally, this approach offers an expedited method to qualitative analysis, which typically would require the researcher to expend additional time after the S^2OPD to make sense of the data collected during the meeting. According to Patton[50] the challenge of qualitative analysis is transforming the massive amounts of data into findings that reveal the essence of what the data reveal. This process would typically be conducted by the researcher, which is estimated that a one hour interview, on average, would yield 10 to 15 single spaced pages of text of transcribed notes. Then, a manageable classification and coding scheme would need to be developed to transform the transcribed notes to identify and label the primary patterns of data. Finally, critical and creative thinking are needed to make judgments about the substantive significance in presenting the findings[50]. The S^2ONA framework eliminates the need to transcribe the meeting, and incorporates the qualitative analysis process into the S^2OPD method.

SUMMARY AND FUTURE RESEARCH

This paper presented a conceptual framework for the S^2ONA, which described the process to elicit and identify the needs of engineering students. Systems engineering concepts are incorporated into the questionnaire development process to define a framework that is centered on understanding engineering student needs. The critical aspects of this approach include:

- A framework that is motivated by student success theoretical perspectives.
- A participatory approach to elicit and identify student needs directly from students.
- A mapping process for translating vague student needs into functionally precise statements that holistically capture the needs of students. This translation process provides decision makers with an understanding of the enablers and hinders of engineering student success, and a guiding structure to develop questionnaire items that describe a concrete set of actionable requirements that institutions must perform to facilitate student success.
- An expedited analysis process that incorporates qualitative analysis into the S^2OPD method.

Research in engineering student success can benefit from the S^2ONA framework presented in this paper to enhance our understanding of those needs that must be fulfilled in order to facilitate student success. An evaluation questionnaire has also been presented in order to assess the S^2ONA as a means to refine and improve the conceptual framework presented in this paper. Based on the results of this framework, an ESN questionnaire will be developed to capture and analyze the needs of students. During this phase of the S^2OSD methodology, institutional decision makers will be assisted in understanding the unique needs of their student population, as well as prioritizing the most important needs, which will then be used to develop improved student success practices.

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Tracee Walker Gilbert
Ms. Gilbert is a Ph.D. candidate in Industrial and Systems Engineering at Virginia Tech. Her research focuses on designing and applying ISE methods and tools to improve engineering education, with particular emphasis on new approaches that will have lasting effects for the success of women and minority students in K-12 and higher education. Prior to pursuing graduate studies full-time, she worked as a Senior Systems Engineer in private industry where she lead projects to develop Geospatial Intelligence Systems from concept through implementation.

Janis Terpenny
Janis Terpenny is a Professor in Mechanical Engineering and Engineering Education, and an affiliate faculty of Industrial & Systems Engineering at Virginia Tech. She is Director of the NSF Center for e-Design, a multi-university I/UCRC center. Her research focuses on process, methods, and tools for early design and on engineering design education. She is a member of ASEE, ASME, IIE, and Alpha Pi Mu and is the Design Economics area editor

for The Engineering Economist and the Associate Editor for Design Education for the ASME Journal of Mechanical Design.

Sharnnia Artis
Sharnnia Artis is a Postdoctoral Researcher in the College of Engineering at The Ohio State University (OSU) where she conducts research in engineering education with a focus on engaging women and under-represented populations. Prior to joining OSU, Dr. Artis worked as a Human Factors Engineering Consultant in the private sector. She received a B.S., M.S., and Ph.D. in Industrial and Systems Engineering from Virginia Tech.