Research to Practice: Keeping STEM student recruitment fresh and relevant using peer mentoring

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***Abstract*— This work in progress paper in the research-to-practice category focuses on high school students planning to enter a new learning environment for transition. Prospective students benefit from structured programming that considers two factors. First, the college knowledge required to navigate day-to-day logistics including new living arrangements, supporting physical & mental health, and funding the experience. Second, STEM curricula and challenges students from extremely rural communities face in identifying with these rigorous programs. The work of influential researchers in student transition and retention along with contextual findings from a large, rural state in the Rocky Mountain region informed the redesign of an engineering college's outreach program. This paper has two purposes. First, it details how established theories combined with research findings and assessment can create robust models to support keeping recruitment programs relevant. Second, it provides an example of how a model was developed and then used to redesign and assess an outreach program using college peer mentors to support high school-aged students interested in engineering and computing disciplines.**

Keywords — research-to-practice, outreach program design, design thinking, computational thinking, backward design, Next Generation STEM, pracademic approach

I. Introduction

Fostering development in the next generation of STEM expert compels higher education professionals to stay fresh and relevant in their practice [1]–[3]. Meeting student needs and supporting their academic success informs methods used to construct programs for these purposes. Disciplines have their own terminology for describing this design process, for example: computer scientists use "computational thinking;" engineers use "design thinking;" and educators use "backward design [4]–[6]." Briefly explained, these terms all describe how experts in these fields identify problems, consider the desired outcomes, and thoughtfully design methods to create solutions.

Regardless of the term used, the process of intentionally organizing structured programs to address problems of practice is what pracademics do with scholarly research [7]. Practitioners who focus primarily on student success in higher education are increasing and their contribution to STEM disciplines is valuable [8], [9] The goal is to increase their impact on populations they served and increase student persistence [10]–[13]. Using findings from a higher education research team and advice from seminal researchers on the topic of college student retention, a model was developed to meet the needs of current High School-aged Students (HSaS) as they consider STEM degrees and prepare to transition to college [11], [14]. This Research to Practice project explains the constructs of the Next Generation STEM model (NG-STEM model) and how it was used to redesign an outreach program, *Shadow Day*. Designed as a recruitment event, Shadow Day orients prospective students to engineering and computing disciplines. Initially, state-wide interest in this program was vibrant and exceeded participant capacity. In recent years attendance sharply declined even with efforts made to promote the event. Informal feedback suggested severe weather, conflicting high school activities, and interest in a more structured event as factors informing participation. It was determined this program needed to be redesigned.

II. Literature Review

A. Moving Toward Action

Vincent Tinto [15], Alan Seidman [16], and Alexander Astin [17], influential researchers on the topic of college student retention, provide advice using the abundance of higher education research for academic success programs. Utilizing existing research and effective assessment strategies in a contextual location puts scholarly research to work on recognized problems of practice. Seidman argues the abundance of retention programming has not had the outcome desired within the Higher Education community and suggests a need to be more intentional with current programs in order to meet students where they are and move them along [18]. Tinto adds to Seidman's perspective suggesting theory can be used to create a working model, but there are important components to include: expectations, support, assessment & feedback, and involvement [19]. Astin reminds us that as practitioners we are trying to support developing professionals which requires an understanding of the environment students are moving through and its impact on their growth [20]. To do this, effective and timely assessments are necessary and support the pracademic's questioning of: "What are we doing?" "Why are we doing it?" and "Is there something we can be doing better? [21], [22]"

Tinto explains the four critical components for model development briefly described here [19]. First, expectations set the stage of engagement for students by providing a target to direct their efforts. Next, support includes academic, social and

financial factors and providing information for students based on their needs. Third, assessment & feedback is beneficial for both participants and organizers of an experience providing data that informs next steps. Finally, involvement could also be referred to as engagement of subjects with their environment in a manner that is meaningful and inspires knowledge acquisition [19]. Using the ideas from Tinto's work and the encouragement from Seidman to establish an intentional approach, first a theoretically grounded model was developed and then used to redesign Shadow Day, a college outreach & recruitment program.

B. *Next Generation STEM Model*

The NG-STEM Model (See Fig. 1) takes into consideration the four components Tinto describes as important for model development and the idea of meaningful engagement he, Seidman, and other student success researchers have empirically supported [18], [19], [23]. Overall, this model was designed with the idea of involving prospective Next Generation STEM (NG-STEM) students in a simulated academic experience that introduced them to engineering or computing as academic disciplines. This model is theoretically grounded in the work of Lev Vygotsky and his *zone of proximal development* perspective [24]. Engaging students with slightly more experienced peers promotes their development and provides just enough support to help them succeed [24].

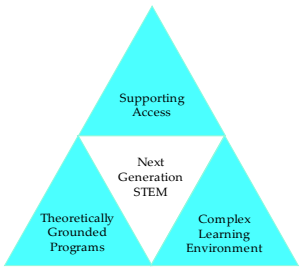

Fig. 1: NG-STEM Model

Peer mentors are an effective strategy in student retention as they are often seen as approachable and authentic in teaching how to navigate the complex learning environment of a university and challenging curricula [25]–[27]. Ultimately, the goal of this Shadow Day program is to support access to STEM majors offered in the college. This purpose aligns with the college's mission and that of its' Land-Grant University which is to educate the sons and daughters of the citizens in the state [28]. The final component Tinto discusses, and Astin's I-E-O assessment method supports, is feedback for constant improvement which was built into the is model [19], [20].

C. *Shadow Day Restructure*

Using the NG-STEM model, peer mentoring research [29], and the work of the Blueprints Research team [30], [31], the Shadow Day outreach event was restructured. The previously loosely structured agenda (see Table 1) was determined to be misaligned with the model and contextual research findings.

Table 1: Shadow Day Agenda - Old Structure

Original Agenda Components
▪ Campus Adventures with college student host *(activities may include: "how to do college" game play (Crash Course), tour of campus, tour of college, shadow classes, shadow labs, explore academic help centers, and more)*
▪ Lunch with host (provided) and participant survey
▪ More Campus Adventures with student host

Participant data indicated high school students were anxious about the unfamiliar world of higher education [30] and current college students valued interactions with peer mentors [31]. Further information relating to the time of year the event occurred was also considered in relation to severe weather and accessibility for participants from remote locations.

The new structure aligned with program goals and the NG-STEM Model to create a robust, college-readiness experience and took advantage of resources and strategies designed to demystify college and STEM disciplines (see Table 2). Six program goals were identified: 1) Recruit and prepare a diverse population for STEM degrees; 2) Socialize and prepare high school-aged students (HSaS) for STEM degrees; 3) Outreach to public, private, and homeschool education; 4) Pairing a high school student with a college peer mentor; 5) Demonstrating what engineering and computing curriculums teach; and 6) Teaching college knowledge skills. Creating opening and closing presentations set expectations for how HSaS should engage with their college student host. A question & answer panel provided an opportunity for HSaS to become comfortable asking questions about anything from academic demands to ways to pay for college. High school students and their hosts were invited to test their strategy through a college simulation board game, led by a peer "game master." Pulling on the faculty influence, the capstone event of the day, a sample engineering & computing design class, was organized to provide a sense of how these disciplines come together to solve problems. Finally, a participant survey was administered during the two hour lunch window of the event [19], [20].

Table 2: Shadow Day Agenda - New Structure

New Welcome (AM) Components
▪ Pre-event Ice Breaker
▪ Welcome Presentation
▪ Burning Questions Panel with college peer academic leaders
Original Components Retained
▪ Campus Adventures with college student host *(activities may include: "how to do college" game play (Crash Course), tour of campus, tour of college, shadow classes, shadow labs, explore academic help centers, and more)*
▪ Lunch with host (provided) and participant survey
New Farewell (PM) Components
▪ Sample Engineering/Computing Design class
▪ Farewell in class – Thank you for Coming

III. Methods

This project used Alexander Astin's, I-E-O assessment framework and a goal-based approach to conduct a formative review of the Shadow Day outreach program [20]. Astin's 3-part framework considers the skills or mindset students (inputs) are bringing with them to a particular experience (environment) and the desired knowledge or abilities (outcomes) a particular experience is meant to develop [20]. Using a goal-based evaluation approach is described by Conrad & Wilson [32] as a method of measuring a program's alignment to established goals and its value to participants. This model of assessment is a tool

for obtaining feedback to understand the role an experience (Shadow Day) plays in supporting student knowledge of engineering and computing as academic disciplines and perception of their potential academic success [20].

Using a 10-question, paper survey instrument, Shadow Day HSaS participants were invited to provide feedback related to their experience. Questions included two, 5-point, Likert-scale questions (1 = Strongly Disagree to 5 = Strongly Agree) and 2 open-ended questions asking what else participants might have wanted to learn. Surveys were informally administered during the lunch portion of the day by being placed on the tables with pens. Event organizers invited participants to provide anonymous feedback on the event through paper surveys. Completed surveys were collected and placed in a central location for review after the event. Survey responses were keyed into an Excel document for analysis. As a "refreshed" outreach program the purpose of this program assessment was to gather baseline data to inform goal alignment and value to participants.

IV. Results

Using descriptive statistics, survey data was analyzed to measure participant feedback to the Shadow Day outreach program [33]. This analytical approach was intentional and meant to establish a benchmark for how the event met program goals [32]. Shadow Day participants were from Montana High Schools across the state with the majority traveling an average of 2 hours to Montana State University. Approximately 60% of Shadow Day participants completed a feedback survey. Table 3 details the gender breakdown of HSaS participant population and survey participants.

Table 3: Shadow Day participants and survey participants

Gender	Participants	Survey Participants
Male	31	22
Female	15	5
Prefer Not to Identify	0	1
Total	46	28

Table 4 details participant perception of college and STEM curriculum preparedness and the slightly higher confidence in college readiness than STEM curriculums. The inclusion of the

Table 4: College and STEM curriculum preparedness

	College	STEM
Strongly Agree	12	13
Somewhat Agree	14	13
Neither agree nor disagree	2	1
Somewhat disagree	0	0
Strongly disagree	0	1
Total	28	28

Success Prints Crash Course board game may have been a factor. The board game is research based and was facilitated by game masters trained to facilitate conversations about engagement, academic strategy, and management of stress. One participant noted in the additional questions portion of the survey that *"The game gives a good insight of [how] each type of engineer thinks about how to play the game…"* It is important to note only 10 of the 28 survey participants reported playing Crash Course and they were all male high school students.

Finally, Table 5 shares questions participants still had at the time they completed the survey. These questions align with findings from Oliveri, Funke, Clark & Seifert [30] as they played a "Jeopardy-style" game with HSaS across the State of Montana. While there is some interest in classes and understanding the importance of engineers, mostly these questions speak to financial worries and how they will fund their academic goals.

Table 5: What they still want to know

About engineering and computing
What are the required classes for your major?
Why are engineers important?
Clubs for CDE's?
About going to college:
How do I transfer credit from high school dual credit courses?
How will I be able to pay for it?
Is it as bad as it seems?
What is the best way to earn scholarships?
Where do you go as a Freshman?
Hangouts outside of this school?
How was their first year?

V. Discussion/Limitations/Implications

The goal of this project was to revise an outreach and recruitment program that had been declining in attendance. Through discussing the concept of design thinking as a means of deconstructing a problem there was an immediate recognition of similar terms and methods in other disciplines. Connecting disciplines by recognizing these similarities widens access to existing approaches that meet the needs of specific populations of students. Learning that while terms might differ, the core meaning acts as the connecting factor was a watershed moment. Developing the NG-STEM Model used current theory and research to deconstruct the problem of a struggling outreach program for the purpose of identifying what was broken so solutions could be identified. What engineers and computer scientists do to solve problems in their fields is no different than an educator's task. The difference is educators are often solving messy problems that are not solved so much as they are dissolved by managing for factors that do not go away, such as being a women in STEM or the First-Generation college student in a family [34].

Existing theories create a systematic framework to address institutional response to student persistence as it pertains to their unique populations [16], [19]. Using these systems as a means of structuring programs with a formative assessment approach provides the tools to create a model and address the contextual problems related to a particular population [19], [20]. The NG-STEM model used the influence of seminal retention researchers Tinto [15], Seidman [16], and Astin [17] along with Blueprints research [30] and Vygotsky's perspective [24]. Focusing this model on a specific population to refresh a college outreach program increased the effectiveness and interest to the target population. Additionally, it aligned program components with established goals which informed the event's design.

Key limitations with this study should be identified. First, this was a problem of context and limited to HSaS in a large, rural Northwestern state. Second, attendance was limited to manage for logistical changes the new structure presented. While the NG-STEM model provides a framework to consider in designing programs, the new program structure may not be transferable to other settings. Third, the survey was distributed at lunch time to accommodate participants who had to leave early potentially influencing responses. In addition, it was difficult to determine the impact of the college practice game because not all survey participants had an opportunity to play. These limitations have informed changes planned for the next implementation of this annual event, including using an online survey and adding more time to include game play as one of the global activities.

VI. Conclusion

Making the decision to refresh a declining outreach program was easy because our team recognized it was no longer seen as a valuable experience to the target population. The more challenging part of this project was considering the theoretical framework that would inform the design of Shadow Day along with other outreach programs. Using advice from key researchers in student retention and current findings of a team who had studied the concerns of today's Montana HSaS provided an intentional approach to this task [18]–[20], [30]. In addition to survey data, anecdotal evidence from participants and the NACOE student club teams who facilitated the event confirmed the team's decision to revise and refresh this outreach event was timely. The value of an intentional approach to this process is it allows practitioners to be true "pracademics" and use scholarly research to consider what we are doing to support student success, why we are doing it, and how we can do it better.

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