Improving undergraduate STEM student success through scalable Peer Mentorship

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This blog post seeks to introduce readers to near-peer mentorship as a possible approach to improving undergraduate student outcomes at post-secondary institutions, and the specifics of the Biology Mentoring and Engagement (BIOME) program which I co-developed at UCSB. The impact of this program was published in *CBE-Life Sciences Education* and resulted in an NSF-funded project to create a second-year near peer-mentorship program.

1. Current challenges to STEM undergraduate student success

In order to meet an increased demand for individuals trained in STEM, there have been an increasing number of calls for changes to existing educational structures to increase the quality, number, and diversity of graduates (National Academy of Sciences, Engineering, and Medicine, 2019; National Research Council, 2009; 2015). However there remains a significant barrier to the continued growth and diversification of STEM fields: the attrition of students who matriculate in STEM, but then switch majors or leave the university altogether. Most of this attrition occurs within the first two years of the college experience (Tinto, 1988; Tinto, 2006), and there is a disproportionate number of students leaving STEM from minoritized student populations (MSPs; Chang et al., 2014; Eagan et al., 2017; Riegle-Crumb et al., 2019).

Students' rationale for leaving STEM is multifaceted, reliant on the intersection of academic experience, performance, and non-cognitive perception (Chang et al., 2014; Eagan et al., 2017). Research has identified that retention in STEM relies on student social integration, fostered interest, and self-efficacy (Estrada et al., 2011; Solanki, et al., 2019). However, in public universities which often rely on non-interactive, large-enrollment courses, it is difficult to provide students with experiences that lead to increased retention.

One effective strategy is immersive research experiences where students join laboratories and receive personalized mentorship; however, at large research-intensive public universities, only a fraction of the student body obtains mentorship opportunities to facilitate this personalized attention through research experiences based on an apprenticeship model (Estrada et al., 2018; Maton et al., 2016). However, independent research as a form of mentorship is difficult to scale. At UCSB, the STEM student:faculty ratio can reach ~50:1, making it difficult, if not impossible, to provide all students in these programs with meaningful faculty mentorship. In fact, STEM undergraduate enrollment in STEM majors continues to climb at the University of California, which represents a larger nation-wide trend (Fig 1).

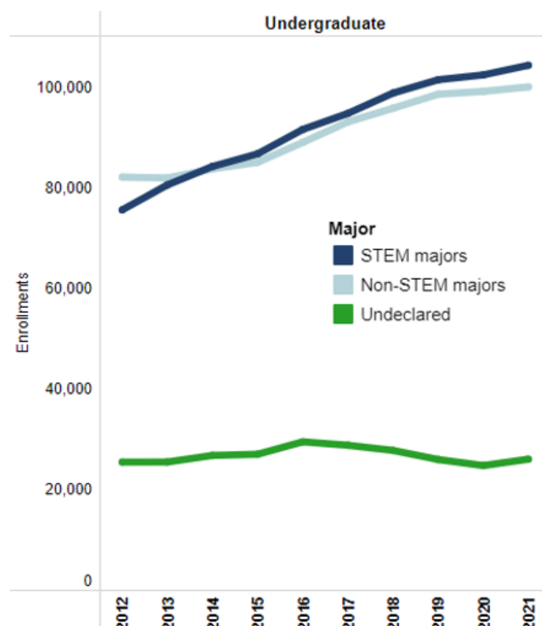

Figure 1. Historical undergraduate enrollment in STEM and non-STEM majors at the University of California. STEM enrollment has grown to 104 000 undergraduate STEM majors currently.

Thus, we turn to near-peer mentorship, the focus of this post, to create these support structures. Near-peer mentorship generally involves pairing lower-division undergraduates with upper-division peers who have similar goals and backgrounds, with the mentor aiming to provide personalized guidance on navigating the complex university system.

2. Peer mentorship as a scalable model

a. Prior research

Near-peer mentorship has been in existence for college students for decades and to date the research literature about near-peer mentorship shows promising results. The majority of studies however do not use research designs that support causal inference and therefore the extent to whether these programs are effective is unclear. Furthermore, studies often focus outcomes on mentees and leave out important conditions about mentors that make programs work. And lastly, most published near-peer undergraduate mentorship programs focus on the first year experience; (Solanki et al., 2019; Wilton et al., 2021). However, prior studies have documented that students' second year of college (referred to as sophomore year here) is a high risk period of departure from college or from one's major, especially among MSPs (Ishitani, 2006; Sterling, 2018). As an example, retention data within the Biology major from our two study sites reflects this pattern, showing greater loss from the major at the end of the second year, and disproportional loss of MSP from the major.

b. Current research

Research exploring the relationship between undergraduate mentoring and student development is guided by a number of different theoretical frameworks (Gershenfeld, 2014; Lane, 2020). The theory most often applied to undergraduate mentorship programs in higher education is Tinto's integration framework (1993), which posits that students who are integrated into the campus environment, both academically and socially are more likely to persist. A response to Tinto's work has been to implement structured student support services, including mentorship opportunities, meant to simultaneously encourage social and academic integration. Mentorship facilitates social and academic integration in a number of ways (Jacobi, 1991; Ostrove and Long, 2007), notably by providing students with 1) psychosocial support, 2) instrumental support, and 3) academic support (Fig 2, Eby et al., 2013; Kram, 1988; Nora and Crisp, 2007).

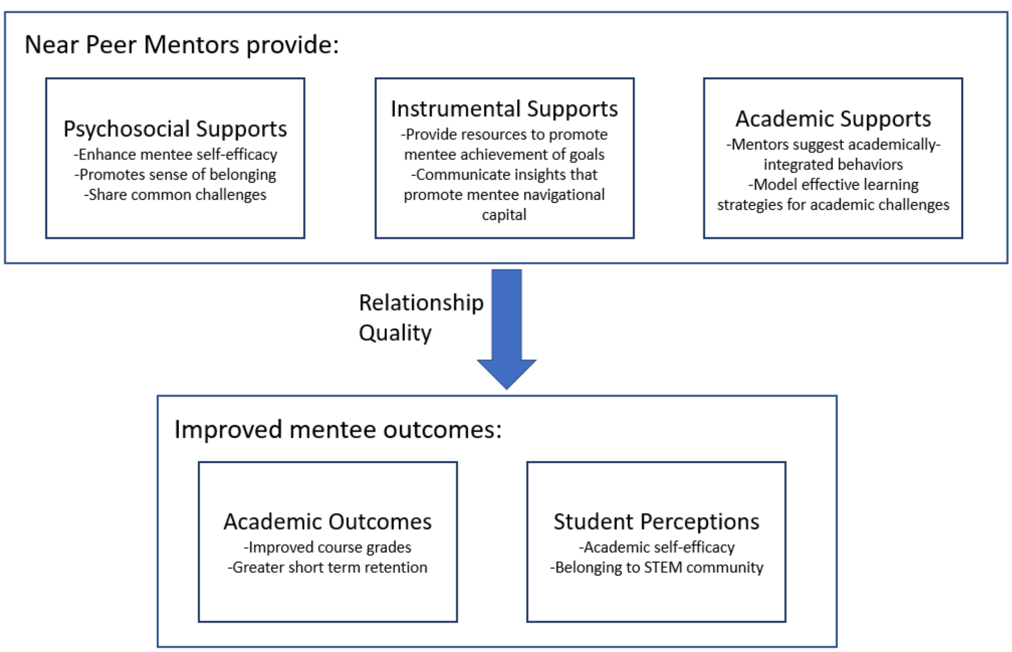

Figure 2. Theoretical model of how mentorship facilitates social and academic integration

1) Psychosocial support refers to mentor behaviors that enhance a mentee's self-perception of competence (i.e., academic self-efficacy) and facilitates a sense of belonging (W. B. Johnson et al., 2007; Nakkula & Harris, 2005; Spencer, 2007). Undergraduates often enter college with uncertainty about their readiness for college coursework, which can create perceptions that interfere with academic functioning and persistence (Hoffman et al., 2002; Shields, 2008). Peer mentors can offer counseling regarding these problems and share their similar experiences, supporting mentees' academic self-efficacy through vicarious experience (Fig 2). Research has shown that addressing common challenges supports student development, particularly in regard to increasing sense of belonging among MSPs (Oyserman and Destin, 2010; Stephens, Markus, and Fryberg, 2012).

2) Instrumental support refers to resources and opportunities provided by the mentor that enable mentees to achieve their own goals. Having experienced the first year of college, near-peer mentors are trusted as role models (Griffin and Romm, 2008) who are perceived as less intimidating than professors (Latino and Unite, 2012). Mentors who can act as a trusted compass, in this way (Terrion, 2012), are particularly important for first-generation college students who may not have similar models at home. Across different contexts, instrumental support has been linked to not only more adaptive academic behavior, but also feelings of belonging and academic self-efficacy (Allen and Eby, 2007; Johnson, 2007).

3) Academic support involves proactively educating, evaluating, and challenging students academically. Through subject-knowledge support, goal setting, skill development, and career advice, peer mentors empower academic success (Miller, 2002; Nora and Crisp, 2007; Schockett and Haring-Hidore, 1985). Similar to the idea of role modeling, peer mentors demonstrate academically-integrated behavior, such as visiting office hours, joining student groups, and using supplementary instructional services. They are also able to help their mentees with course-specific struggles by modeling learning strategies (Cuseo, 2010) Often, academic support is identified as the driving mechanism linking peer mentorship programs to improved academic performance and retention (Johnson, Johnson, & Smith, 1998).

Importantly, the effectiveness of these supports can be related to the quality of mentorship relationships (Rhodes, 2002, 2005). Relationship quality is the degree to which the mentor-mentee relationship establishes feelings of trust, empathy, respect and emotional connectedness to the relationship as a whole (Allen & Eby, 2003; Kram, 1988; Nakkula & Harris, 2005; Rhodes, 2005). The Eby et al. (2013) meta-analysis on mentoring across different contexts (e.g., youth mentoring, academic mentoring, and mentoring in the workplace) found interaction frequency was positively associated with relationship quality in both the workplace and academic setting, as well as a positive correlation between interaction frequency and perceived psychosocial support by mentees. These findings highlight the importance of structuring regular contact between the mentor and mentee.

3. Constructing a Peer Mentorship Program

This section includes four general steps or considerations that individuals interested in implementing a peer-mentorship structure can follow. Below each step I include the narrative of the BIOME program implemented here at UCSB in the undergraduate biology program.

a. Identify a challenge facing your undergraduate mentee population.

The first consideration is to understand the local undergraduate context. What challenges do undergraduate STEM students have in your course, major, or university? These insights can be gleaned by analyzing quantitative student academic record data (grades, retention) and/or qualitative means (anecdotal insights, focus group discussions, surveys [note: surveys can also be quantitative]).

After identifying these challenges, consider the ways in which having a peer mentor could promote greater student success. It is important that you have a good conception of how the mentor will address the challenges faced by your mentees. Will the mentor simply be a tutor (Fig 2, academic support only)? Or on the other end of the spectrum, will the mentor provide all elements of effective mentorship?

At UC Santa Barbara, our first year biology majors enroll in the year-long General Chemistry course sequence prior to Introductory Biology (the chemistry courses are prerequisites). Analysis of student academic performance in these courses was significant in predicting second year student retention in the biology major; further, the General Chemistry courses were the first STEM courses our students enrolled in at UCSB as they transition from high school. Thus, our understanding of the local context was that this course series has a dramatic impact on the trajectories of many of the first year biology students - many leave the major prior to enrolling in a biology course! Thus, we sought to design a peer mentorship program that could help foster the development of rigorous academic soft skills to promote student acclimation to the General Chemistry course expectations.

b. Construct a mentorship framework that provides structure and incorporates elements of the mentorship theoretical model

The next consideration is how to structure the peer mentorship program. Will it be extra/co-curricular? Or will it be in a course? These structures will ultimately dictate how the mentorship program operates. Extra/co-curricular mentorship programs are inherently more flexible and adaptable but this format might limit expectations of mentee commitment; conversely, course-based mentorship programs are more rigid, but can expect greater student commitment (like the incorporation of assignments) as course units are being earned. As part of the peer mentorship program, how often will your groups meet? What will be the topics that guide each meeting and the program overall?

After the structure is solidified, what elements of the theoretical model will your program use? Given the importance of relationship quality between your mentors and mentees, what mentor:mentee ratio will you utilize? There is some evidence that the most effective ratio is 1 mentor: 4-6 mentees.

In our local context, the peer mentorship program is housed in a course series of first-year student seminars each worth 1 unit. These courses are not required in series but do have General Chemistry co-requisites to ensure that all participating mentee students are enrolled in the same contextual course. Class meetings are weekly for 50 minutes and always follow the same structure: a pre-class homework assignment (a reading, video, or podcast on an academic soft skill coupled to response questions) that sets the basis for the mentorship group and class-wide discussions held weekly.

We conceived of the mentors as providing all three elements of the mentorship program and acting as role models, but not tutors (there would be no teaching of General Chemistry in our mentorship program). Given that we wanted our mentors to have deeper relationships where they became familiar with their mentees, our peer mentorship program uses the 1:4 mentor:mentee ratio.

c. Recruiting, training, and compensating your mentors

In considering your mentors who will be acting as role models and providing advice to a diversity of students, think carefully about how student identity and experience at the university informs mentor insights. Thus, it is important to identify and recruit mentors who represent and share common goals with their mentees - this alignment is key to enabling meaningful quality relationships. To recruit these mentors, consider former students and reach out with on campus social/professional clubs, and or advising offices. Use of an application form disseminated via a majors email list-serve is also effective at reaching a broader audience that already shares your mentee's major. It is likely that one would use multiple approaches to recruit a diverse pool of applicants. In person interviews are critical to inform the program about the suitability of applicant mentors.

Training of the mentors is key to ensure that individuals are ready to interact with the diversity of their mentees and the potential situations that may arise. Trainings should at minimum provide mentors with knowledge of the goals of each mentor/mentee meeting and help mentors navigate social, academic, and personal challenges faced by prospective mentees. *We have found weekly trainings where mentors engage in mock discussions as mentees are a useful modality to provide experience and familiarize the mentors with course content prior to engaging with their student mentees. We require our mentors to take a preparatory course on culturally aware mentorship.*

d. Start small, scale after proof of principle

Implementation of a novel program structure requiring mentor recruitment and training, as well as mentee engagement requires considerable coordination of logistics. Thus it's ideal to start with a small cadre of trusted near peer mentors to help with the initial offering of the program. In the first iteration, challenges and changes in program delivery will occur that will enable you to refine the program goals and structures. After an initial iteration or two, scaling to a greater program size is feasible once elements have been solidified into the appropriate timeline of the course. As your program proceeds, collect student academic data (grades, retention) as well as non-cognitive and qualitative feedback on what is working well (or less well).

Initially our mentorship course recruited six mentors who mentored two groups of four-six student mentees during two separate course times. Feedback from the mentors and mentees over the first two offerings of the program enabled us to optimize each assignment on a relevant and timely soft skill as well as move course assignments to more closely align with the General Chemistry *course series*. *More recently with a finalized course structure, we have recruited 30+ mentors and have enrolled over 200 first year undergraduate students. This scaled up approach enabled us to assess the academic outcomes of our mentorship program as explained here.*

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