Working Paper

Supporting Student Learning Outside the Classroom: 
A Research Agenda for STEM Academic Support at the Undergraduate Level

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Introduction

Over the past two decades, tremendous resources have been channeled toward revising STEM curricula and classroom pedagogy in US higher education, with widespread research attention focused on identifying the elements of inclusive, engaging, and effective teaching and learning. This work has ushered in a new era of pedagogy in STEM, and has improved the STEM learning experience inside the classroom for countless undergraduates.

Far less research attention has been directed toward the practices that surround the student’s STEM classroom experience to support learning: academic support in the form of tutoring, formal group study, academic coaching, and the like. Given that these support activities are typically a salient feature of the student academic experience, and one which in many institutions occupies a formal place within the organizational structure, decision-makers need an understanding of what works well, for whom, and why. This paper provides a high-level agenda for research into academic support practices in STEM undergraduate education.

What do we mean by academic support?

For the purposes of this document, we define academic support as guided activity typically provided outside of the regular classroom, intended to enhance students’ ability to succeed in their courses. Such support might take the form of tutoring, peer study groups, office-hour support, academic coaching, and so forth. This support is often provided through student learning support centers, but in many instances comes from faculty, advisors, or other institutional units (e.g., academic departments, schools). Within the academic-support domain, we focus in this paper on

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1 It should be noted that a substantial body of research exists on the broad area of developmental education; see Jaggars & Bickerstaff (2018) for an overview.
undergraduate-level coursework and on STEM course content - mathematics, natural sciences, engineering, computer and information sciences, and the social and behavioral sciences.

Although curricular and pedagogical reforms (i.e., activities taking place within students’ regular classroom experiences) are vital to undergraduate education, these are beyond the scope of this paper.

Development of the agenda

In summer 2019, a group of approximately 100 STEM learning professionals, including this paper’s authors, gathered at a National Science Foundation–sponsored meeting at Northwestern University in Chicago. This group included disciplinary faculty as well as learning-support professionals at a variety of higher education institutions across the US, as well as Canada. Our goal was to develop priorities for research into undergraduate STEM academic support, with the larger aim of setting a path toward better informed and more systematic decision-making around academic support programming in colleges and universities.

As part of the conference development, the organizers developed a literature review focusing on five areas critical to STEM academic support:

1. Structure and form of academic support
2. Psychosocial factors in academic support
3. Social identity and diversity in academic support
4. Metacognition and self-regulation in academic support
5. Institutional factors and partnerships shaping academic support

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The literature review was used as a loose framework for the conference activity. Participants broke into groups according to interest area, one assigned to each of the five topics. They then engaged in a series of four structured conversations, first to identify key areas of concern within the broad topic; then to refine these; then to articulate those concerns as research questions; and finally to refine those research questions. Following the conference, a small subset of attendees – this paper’s authors – met over several months to further distill the refined research questions within each of the five categories, eliminating redundancies, deleting questions that fell outside of the core focus area of support for academic work, and prioritizing topics that had emerged multiple times during the original discussions. Through this process, we identified a set of core research questions, which we lay out in the sections that follow.

**Structure of this report**

The report addresses each of the five broad topics listed above in its own section, first offering a brief overview of the topic, then outlining the critical research questions identified under that topic, and exploring key research which provides background and potential framework for studies investigating those questions.

**Methodological notes**

Although general guidance on educational research methods is outside of the scope of this paper, we offer two key methodological notes below, which apply to any study of STEM academic support. (We also offer more specific methodological suggestions throughout the paper to provide researchers suggestions on pitfalls to avoid and approaches likely to yield valid, reliable, and generalizable results.)
1. **Determining what constitutes “success.”** Studies of programming aimed at improving student academic outcomes — whether implicitly or explicitly — must define what a successful outcome is. What outcomes do we care about? Are we interested in performance on a given measure, or long-term learning? For instance, is our goal to improve academic knowledge, or social and psychological well-being within the academic context, or both? We recommend that questions such as these be explicitly considered in the development of any study of academic-support activities, and that the rationale for choosing particular outcome measures in any study be included in any research report.

For the purposes of this paper, we have left the definition of desired outcomes up to the individual researcher to determine, so that the research questions we present are stated in fairly broad terms. However, we encourage researchers to consider the following questions as they identify outcome variables of interest:

a. What are the particular goal(s) of the activity or program under study? For instance, was the activity designed to improve grades in a given course? For everybody, or for students with lower incoming grades, or some other group? To improve retention or graduation rates? To improve the sense of belonging in a department or major? Is an increase in the overall number of participants or in certain subpopulations desired, or is the quality of the experience more relevant than the quantity of participants?

b. How can we most meaningfully operationalize success indicators? For example, does “improvement in grade” mean any improvement? An improvement of a particular magnitude? An improvement relative to some previous assessment score?

c. What are the most practically meaningful outcomes for the particular students (or other constituents) in the study? For example, is grade improvement the result that
is most likely to allow students to achieve their short- or long-term goals? Is demonstrated understanding of particular concepts more relevant than grade, given those goals? Are psychosocial outcomes, such as belongingness or confidence, equally or more important in achieving those goals?

2. **Comparison groups and self-selection in evaluation research.** When we examine whether a particular intervention is successful, a meaningful point of comparison is needed in order to judge the relative change in outcome variables. In some cases, the point of comparison is the participants (students or other constituents) themselves at a previous time point; in others, it is a group of participants that did not take part in the intervention. True experimental designs, which integrate random selection and control groups, allow researchers to draw conclusions about the causal impact of an intervention; however, they are often difficult to carry out in educational settings. Only a small number of academic-support programming studies have used experimental design (e.g., as with Arco-Tirado et al., 2011). Others have used quasi-experimental methods (Shadish et al., 2002) such as nonequivalent comparison group design (Colver & Fry, 2016; Gattis, 2002) to investigate causal effects or minimize self-selection effects, or the extent to which students who opt into support programming may be predisposed to do well because of factors other than the support programming. Self-selection is a concern in intervention studies where students can opt in or out of the program under study. Pre-existing differences between students who opt in and those who do not, for instance differences in motivation, high school GPA, or executive control skills are sometimes ignored in evaluation studies of academic-support programming (Van der Meer & Scott, 2009). Such variables can confound the results of an analysis, making it appear as if the intervention is responsible for some observed change when in fact a third, underlying factor
was at play. Researchers can also use techniques such as propensity score matching (White & Sabarwal, 2014) to minimize the impact of potential third variables.
Research Area 1: Structure and Form of STEM Academic Support

Academic support in STEM comes in many different forms (e.g., tutoring, peer-led study groups, academic coaching, workshops) and these forms have been researched to various degrees. We provide an overview of research on several of these forms below.

Peer tutoring. Peer tutoring comes in many flavors, varying across multiple dimensions, such as the content of the curriculum, the ratio of tutees to tutors, tutee and tutors’ year of study, experience, skill levels, and compensation of tutors and tutees, whether the tutor and tutee roles are continuous or rotational, the content and methods of tutor training, where and when tutoring takes place, the objective of tutoring, whether the tutoring is voluntary or compulsory, and whether reinforcement is used. Much research on drop-in tutoring (Gerlaugh et al., 2007; Holliday, 2012; Perin, 2004; Perkin & Croft, 2004; Santee & Garavalia, 2006; Ticknor et al., 2014; K. Topping, 2001) uses quantitative analysis examining tutees’ subjective experience, grades, or GPA as a function of seeking out tutoring one or more times. Such studies usually show positive relationships between tutoring and desired outcomes (Fullmer, 2012; Gallard et al., 2010; Hughes et al., 2011; Rath et al., 2012; Rheinheimer et al., 2010), although some have not produced positive outcomes (Cooper, 2010; Navarra-Madsen & Ingram, 2010; Topping, 1996).

Peer-led learning. Peer-led learning is one of the most common forms of support, but its shape and structure vary (see Arendale, 2017 for a typology and review), depending on the institution and the program. Peer-led team learning (PLTL) is perhaps the most common and most researched peer-learning model in STEM: it involves collaborative work outside of class, focused on problem sets, for groups of 6 to 8 or so students, and led by a trained peer (Gosser, 2001; Gafney, 2001). Small-group study models similar to PLTL have also received attention in the literature; these share many of the features of the model but may differ in the degree of faculty involvement or session activities. Another peer-led learning model, Supplemental Instruction (SI), was started at
University of Missouri and has been adopted at over 300 institutions in the United States and internationally. Very similar models are referred to by other names, such as Peer-Assisted Study Support or PASS (see Dawson et al., 2014 for a review). SI involves later-year student leaders, who attend all classes and lead study sessions for other students once or twice a week, usually in STEM courses with high failure or withdrawal rates (Dawson et al., 2014). Both the PLTL and SI models require relatively high levels of staff and/or faculty involvement in training peer leaders and developing or overseeing session content.

Studies of these models have shown improvements in academic performance, retention, and attitudes about the course, as well as sense of community and persistence (Amstutz et al., 2010; Arendale, 2017; Carlson et al., 2016; Drane et al., 2014; Gafney & Varma-Nelson, 2008; Gosser, 2011; R. Hodges et al., 2001; Kochenour et al., 1997; Martin & Arendale, 1990; McGuire, 2006; Micari & Pazos, 2019; Pazos et al., 2007; Ruiz-Primo et al., 2011; Shook & Keup, 2012; Tien et al., 2002). There is also some evidence of a positive relationship between participation in group-based programs and students’ feelings about the course, study skills (Court & Molesworth, 2008; Ning & Downing, 2010), and confidence in asking questions (Dobbie & Joyce, 2008; Longfellow et al., 2008; Mahdi, 2006; Van der Meer & Scott, 2009). In addition, a stronger positive relationship of program participation to grades has been observed for students with low levels of preparation than for those with higher preparation levels (Micari & Pazos, 2019).

**Study-skills programming.** Universities also commonly offer study-skills support to students, aimed at improving their STEM learning and performance more indirectly, by focusing on how to study rather than what to study. This kind of programming is typically offered through a university academic-support center, via workshops, modules that stand alone or are embedded into courses, or one-on-one coaching. On the whole, the effectiveness of workshops and seminars has been understudied, and very little systematic research exists. There is, however, some evidence for
increased learning skills in students engaging in study-skills courses (e.g., Hoops et al., 2015; Wibrowski et al., 2017) with a structure similar to many workshop series. There is likewise little research to support the effectiveness of academic coaching for university students. One notable exception is an evaluation of a proprietary technology-enhanced coaching system (Bettinger & Baker, 2014), which produced greater retention and completion rates as compared to a control group, although it should be noted that the dataset for the study came from the coaching firm itself. More generally speaking, academic advising broadly defined has been shown to be positively correlated with perceived learning gains, student retention and satisfaction (e.g., (Barbuto Jr et al., 2011; Kohle Paul & Fitzpatrick, 2015; Metzner, 1989; J. Smith et al., 1992; Tinto, 2004; Vianden & Barlow, 2015), and increases in students’ academic planning (Smith & Allen, 2014). However, the research on overall advising effectiveness, especially comparing across institutions, is limited (Hagen & Jordan, 2008). As with forms of tutoring, advising appears to be more effective the greater the frequency and number of advising meetings, because more meetings allow more topics to be covered and the advising relationship to develop more fully over time (Frost, 1990; Swecker et al., 2013).

All these forms of academic support traditionally take place face-to-face, although there has long been some degree of virtual tutoring, advising, and other services available. The COVID-19 pandemic, however, prompted a large-scale shift to online academic support of all kinds (C. Johns & Mills, 2021). Transitioning to online tutoring, study groups, coaching, and other support programming has involved reimagining these services through the use of online platforms such as Zoom, Slack, Discord, and Microsoft Teams, and the increased use of calendar applications and event-organizing software for scheduling individual tutoring or other appointments. The research into the relative benefits of virtual vs. in-person support, and the features which enhance the benefit of virtual support, is small but growing (Brummernhenrich & Jucks, 2013; De Smet et al., 2008; Hanham et al.,...
2021), although there is already a substantial body of literature more generally focusing on virtual communication and virtual learning.

**Critical Research Question 1: What is the relative impact of various tutoring models on student outcomes?** Particularly relevant comparisons include the following: Individual vs. group-based tutoring; appointment-based vs. drop-in tutoring; remote vs. virtual settings; and professional vs. peer tutoring.

Overall, far less research exists on the impact of tutoring programs than on sustained group-study programs, most likely because tutoring encounters can be one-off and brief, making impact more difficult to capture. Few studies qualitatively analyze which kinds of interactions during tutoring are most effective for student outcomes (see DeFeo, Bonin & Ossiander-Gobeille 2017 for an exception) and few use any type of comparison group. Further, because of sample size constraints, most studies lack statistical power to examine differential effects of tutoring on underrepresented groups or to determine the relative effectiveness of different forms of tutoring. Additionally, few studies detail the type of training that tutors receive (see Critical Research Question 5) beyond noting the use of broad models (e.g., the College Reading and Learning Association tutor training program certification), which can vary in implementation (Colver & Fry, 2016). Finally, there is very little evidence on the relative effectiveness of various approaches to training, under what circumstances, or for whom.

**Critical Research Question 2: What is the relative impact of various models of academic support across subpopulations of students?** For example, how do demographic group, referral status (self-referred vs. referred by advisor), probationary vs. non-probationary status, etc., impact the effectiveness of academic support? In particular, does the impact differ across students who do and do not hold marginalized identities?

Within the group-based support literature, there is some evidence that the relationship between participation and desired outcomes can be higher for students with marginalized identities.
than for other students, as well as for students with lower levels of preparation as compared to those with more preparation (Drane et al., 2014; Micari & Pazos, 2019; Peterfreund et al., 2008). However, there is limited research about how various forms of support might differentially impact particular subgroups of students. We know little, for example, about how specific STEM support models and approaches work for students with marginalized identities or first-generation students, or for students who come to support voluntarily versus those who are referred to, or required to, access support.

Although research suggests that traditional models of support, such as study-skills workshops or courses and academic coaching, are moderately successful, students may not successfully transfer more generic study skills to their course-specific learning (Drummond et al., 1998; Durkin & Main, 2002). Study-skills support might be more effective if it is embedded within a course, or within course-specific support like tutoring, providing opportunities for students to practice study strategies with course-specific concepts (Wingate, 2006). However, there are no existing evidence-based models available for integrating study-skills mentoring with course-specific tutoring.

A methodological note: the effectiveness of STEM support programs has been evaluated in a variety of ways, some of which provide stronger evidence than others. The most common outcome variables have been course completion and final course grades. Some studies include pre- and post-intervention data (e.g., Congos & Mack, 2005; Fayowski & MacMillan, 2008), whereas others utilize a comparison group (Gattis, 2002; R. Hodges & White Jr, 2001; Parkinson, 2009). Outcome variables have also been correlated with student attendance by comparing students who attended more or fewer sessions (Cheng & Walters, 2009). Further, a number of studies have examined or controlled for self-selection by including measures of motivation, GPA, or standardized test scores prior to the course. However, many studies still do not account for self-selection, which makes claims regarding a program’s effectiveness impossible to judge.

Critical Research Question 3: Within group support settings, what impact does group composition, in terms of academic preparedness and demographic characteristics, have on student outcomes?

Although there is a sizable literature on the impact of group composition more broadly, including within the K-12 arena and in the workforce, there is very limited research examining the composition of small-group learning at the college level. Overall, evidence is mixed, perhaps due to methodological differences among studies. In studies on K-12 education on the effects of grouping by preparedness level, there is some evidence of a benefit to grouping, but other studies show a detriment, and yet others show differential effects for students at different levels of preparation (Gijlers & De Jong, 2005a; Leonard, 2001; Saleh et al., 2005). In the college environment, Micari et al. (2016) found that diversity in academic preparation benefitted student grade outcomes, but that less-prepared students did not fare well in groups dominated by highly-prepared students. Micari & Drane (2011) found that differences in perceived ability were negatively correlated to students’ engagement within the group and eventual course outcomes. Baer (2003) found a positive relationship between grouping by academic preparedness level and student outcomes.

The demographic makeup of study groups in the context of academic support has not received much attention in the literature, but research on learning groups within STEM courses points to important gender-related effects. For example, Dasgupta et al. (2015) found that female engineering students had more positive outcomes when they were in female-majority learning groups than in more mixed groups. In regard to racial or ethnic factors in group composition, there is very limited research at the level of small learning groups or at the college level. Although there is an extensive body of research on racial and ethnic diversity in classrooms, the complexities of how such diversity impacts student experience and learning within STEM support environments in particular is limited (see, for example, Fries-Britt & White-Lewis, 2020; Singaram et al., 2011).
Critical Research Question 4: How does the nature of interpersonal interactions during an academic-support encounter impact student outcomes?

Subquestion a: What are the characteristics of interpersonal and conversational dynamics within an academic-support encounter that lead to better academic and psychosocial outcomes for students?

Subquestion b: In what ways are the answers to (a) above different in a virtual environment?

There has been limited research into how the characteristics of interpersonal interactions, such as the questioning practices used by tutors, the turn-taking behaviors within a group, etc., impact student outcomes within STEM academic-support activities (Chai et al., 2019; Chini et al., 2016; DeFeo et al., 2017; Dubey et al., 2017; Oshima et al., 2013; Repice et al., 2016, 2016). For example, scaffolding strategies used by peer leaders (Kulatunga & Lewis, 2013), the level of directedness used by peer leaders, and the degree of depth of problem-solving encouraged in the groups (Micari et al., 2010), have generally shown that a less directive approach (i.e., guiding students in actively solving problems rather than showing them how to arrive at an answer) and greater attention to concepts rather than isolated pieces of information are linked to better student outcomes (Chi, 1996; Rose et al., 2001; K. J. Topping & Bryce, 2004). These findings align with theoretical assumptions that peer learning encourages students to do more meaning-making than memorizing (Repice et al., 2016) and learn more actively (Ashwin, 2003; Knight, 2013). There is a larger, but still modest, body of research on online and reading-based tutoring interactions (Brummernhenrich & Jucks, 2013; Schmidt, 2011). The field is ripe for increased attention to evaluating the conversational characteristics and interpersonal dynamics of effective STEM support encounters. Similar studies of classroom dynamics (Chiu, 2008; Empson, 2003; Sfard, 2001; Webb et al., 2002; Wieselmann et al., 2020, 2021) can provide excellent models for future research.
Attention to these questions within a virtual setting is critical, since communication dynamics differ in important ways between face-to-face and virtual environments, and may differ further depending on students’ identities and personal characteristics (Chang et al., 2019; Ruthotto et al., 2020). A fuller understanding the features of an academic-support encounter which promote student engagement and belongingness will help program designers create more active and inclusive virtual support environments.

**Critical Research Question 5: What approaches to training of peer learning leaders (tutors, mentors etc.) are effective in promoting behavioral and attitudinal changes in leaders, in both cognitive and non-cognitive domains?**

**Subquestion a: Which training activities are most likely to impact leader approach and behavior as related to creating inclusive support environments?**

Typically, academic-support programs that utilize peer tutors/leaders offer the tutors or leaders structured training. Topics typically addressed in such training programs include interpersonal and communication skills (Roth et al., 2001), student regulation of learning and metacognitive skills (Leary et al., 2013; Roscoe & Chi, 2007), small-group dynamics and facilitation (Azer, 2005), diversity and inclusion, including topics such as microaggressions, anti-racism, belonging, stereotype threat, etc. (Lundmark et al., 2017; Roth et al., 2001; Tien et al., 2004), and cognition and learning (Shiozawa et al., 2016, e.g., spaced retrieval, the testing effect). However, the training process varies widely across universities; there is no single standard approach to the amount or timing of training, or to what topics are included, how they are introduced, or how much time is allocated to each topic. That said, institutions may seek certification of tutor-training programs, for example from the College Reading and Learning Association (Wilson & Arendale, 2011), and must adopt some standardized approaches to achieve this.
Some studies suggest that the use of mock tutoring sessions (Baroffio et al., 2007) and video scenarios (Bosse et al., 2010); (Holland et al., 2017) can help tutors learn to navigate difficult tutoring situations. Additionally, some researchers highlight the value of content experts in developing the training curriculum and/or implementing them (Baroffio et al., 2007; Kail, 2003). There is considerable opportunity for more research into which content and training approaches are most likely to change peer leaders’ attitudes and conceptions of the act of providing support, as well as their behaviors within the support relationship. In particular, attention to diversity and inclusion–related training activities could promote positive outcomes for students with marginalized identities. Theory and research from the teacher/faculty development literature focusing on both inclusion (Ash et al., 2020; Chavez et al., 2003; Dewsbury, 2017; Moriña & Carballo, 2017; Wiggan et al., 2020) and related pedagogical practices (Çetin, 2021; Hudson et al., 2015; Jacques et al., 2020; Nardi, 2021; Staub & Stern, 2002) will provide an excellent foundation for this work.
Research Area 2: Identity and Diversity in STEM Academic Support

The research on social identities in STEM education clearly demonstrates a relationship between a student’s social identity and the quality and outcomes of their educational experiences. The picture is multi-faceted and complex for several reasons. First, social identities are many, encompassing race and ethnicity, religion, gender identity, socioeconomic status, disability status, age, sexual orientation, and more. Furthermore, a single individual’s experience will be affected by the intersections of their identities, as well as by other individual factors such as life experiences and personality. Two white, gay men, for example, may have very different reactions to the campus climate at a given university, despite their shared identities. Second, social identities do not exist in a vacuum but rather interact with particular social, cultural, and institutional contexts. A Latina first-generation college student, for instance, will likely have one experience in a highly diverse public institution and another in a private, predominantly white school. Institutions vary in factors such as the diversity of the student body, degree of attention paid to creating inclusive environments, opportunities for faculty and staff training around inclusion, and so forth. Institutions also exist within broader local and national social and political cultures which influence the institutional climate and individual experience. Third, STEM education is not a monolith, but rather a set of varied, structured experiences which can affect a single individual in different ways. For instance, a given undergraduate may have a highly enriching and connected experience in a lab course but feel highly alienated and discouraged in a lecture course, or vice versa.

All this complexity notwithstanding, we know that diversity and social identities matter in STEM higher education. First, there is uneven representation in STEM degree completion. At the undergraduate level, in 2016, women earned 19 percent of bachelor’s degrees in both physics and computer science, and 21 percent in engineering, despite making up 27 percent of the population. The same year, Hispanic or Latinx students earned just under 14 percent of science and 10 percent of
engineering degrees; and Black or African American students earned 9 percent and 4 percent, respectively (National Science Foundation, 2019). For comparison, 36 percent of bachelor’s degrees awarded in 2015-16 were to Black/African American students, and 40 percent to Hispanic/Latinx students (US Dept of Education, 2020).

Second, institutional type makes a difference. For instance, the top 8 undergraduate institutions of female Black/African American STEM doctorate-earners in the US were minority-serving institutions (National Science Foundation, 2019), meaning that predominantly white institutions send fewer Black students on to earn doctoral degrees. Research suggests that minority-serving institutions might promote STEM success via more supportive environments, dedicated faculty mentoring, and readily available academic support services (Museus et al., 2011). Factors identified in the research as suppressing achievement of students with marginalized identities in predominantly white institutions include enacted racism and stereotypes, lack of representation, lack of mentoring and connection to faculty, social isolation, and perceived pressure to prove oneself, among others (Museus et al., 2011). Third, we know that students with marginalized identities face hurdles in institutions of higher education which are not present for students with more privileged identities. Students with marginalized identities frequently report experiences reflective of an institutional climate that devalues their contributions and discourages their confidence (Gusa, 2010; McGee, 2016; Rankin & Reason, 2005; Reid & Radhakrishnan, 2003). Such experiences can come in the form of blatant statements (e.g., comments from faculty with racist or sexist undertones) or as microaggressions that cumulatively and insidiously interfere with students’ ability to learn and perform (e.g., rarely being called on in class, hearing a comment that you may have been admitted because of your race or gender) (Nadal et al., 2014; Wilkins-Yel et al., 2019). Students with marginalized identities, particularly students from lower-income families or who are among the first in their families to attend college, also face institutional cultures and structures that are designed for
those with greater cultural capital and knowledge of the hidden curriculum (Chatelain, 2018); and
they are at high risk for imposter phenomenon (colloquially termed *imposter syndrome*, suggesting a
pathology [Feenstra et al., 2020]), which reduces one’s confidence and can cause anxiety and, in turn,
impede learning and performance (Parkman, 2016; Qureshi et al., 2017). Existing within a culture that
does not value — or perhaps overtly devalues — one’s identity creates pressure to conform and to
modify oneself in order to be accepted. For instance, feeling devalued as an LGBTQ student within a
strongly heteronormative disciplinary culture can lead to anxiety and other health issues, which in
turn impact one’s ability to learn and perform well (Cech & Rothwell, 2018).

Students in STEM with identities for which stereotypes exist around intelligence or ability to
perform also face stereotype threat (Steele, 2011), or the cognitive burden created when one worries
about confirming a negative stereotype about one’s identity group, which in turn impedes
performance (for example, with African American students performing more poorly on standardized
tests when their race is made salient). This phenomenon has been observed in multiple settings
across a wide variety of tasks and identity groups, including groups which by and large have more
social privilege. Studies have demonstrated the effect, for instance, for white men who believe they
are being compared to Asian men in a math test, or white men who believe they are being compared
to Black men in a test of athletic ability (Pennington et al., 2016). Other research has shown similar
effects for women in STEM fields (Shapiro & Williams, 2012), affecting not just performance on
various tasks but also the ability to study effectively (Appel et al., 2011). This can work in the opposite
direction, too. For example, research on “model minorities” has demonstrated that the stereotype
that Asians excel in math can have a detrimental effect on Asian students’ educational experiences
and ability to perform at their best, and reduce their help-seeking behavior (Cheryan & Bodenhausen,
2000; Gupta et al., 2011; McGee, 2016).
**Critical Research Question 1: What programmatic features of academic support are associated with positive outcomes for students with marginalized or underrepresented identities?**

**Subquestion a: How do bias, stereotype threat, microaggressions, and racism play out in academic-support environments, and how can they most effectively be countered?**

Academic support can offer greater benefit to students with marginalized identities than to their non-marginalized peers (Drane et al., 2014; Nasim et al., 2005; Rheinheimer & Mann, 2000). Students with marginalized identities have often achieved success, even more so than other students do, when they participate in smaller, collaborative STEM working groups (Cabrera et al., 2001; Fries-Britt et al., 2010; Treisman, 1992). The largest body of evidence for this claim examines collaborative study groups (e.g., Supplemental Instruction, Peer-Led Team Learning). Some of this research has shown that study groups offer the greatest benefit to academically less-prepared students (Báez-Galib et al., 2005; Drane et al., 2014; Hall et al., 2014; Micari et al., 2016; Shields et al., 2012; Snyder et al., 2016). Still, it is not clear which particular features of such programming are key to producing benefits. Other studies provide inconsistent findings on the impact of group-based programming as related to gender (Chan & Bauer, 2015; Hockings et al., 2008; Tien et al., 2002), racial or ethnic backgrounds (Chan & Bauer, 2015; Frey et al., 2018; Hockings et al., 2008; Tien et al., 2002), and students with different levels of academic preparedness (Lewis & Lewis, 2008). Further, research on collaborative study groups reflects many different programming features and methodologies, making comparison across studies difficult.

The effects of academic support programs on increasing the proportion of and improving the experiences of women in STEM are not well-researched. Some studies demonstrate the importance of practices akin to academic support, such as mentoring (Brown, 2008; Darke et al., 2002; Johnson, 2006; Tate & Linn, 2005; Trenor et al., 2008; Weber, 2011), learning communities, and support groups (Brown, 2008; Espinosa, 2011) to women's persistence in STEM, with limited research into...
more standard academic support services like seminars, tutoring, and study skill courses (Carter, 2006).

Interventions that can be embedded within academic support programming also warrant investigation. For instance, Jordt et al. (2017) showed that a values affirmation exercise can reduce stereotype threat and improve performance of students with marginalized identities — particularly those who held more stereotyped beliefs about gender differences — in a biology class. This exercise has also been shown to improve women’s intellectual performance (Martens et al., 2006; Miyake et al., 2010). In a similar vein, Christopher (2015) found that reframing the perception of the purpose of a test, teaching students to celebrate struggles, and creating positive stereotypes were effective in reducing stereotype threat and improving performance in law students. Translating interventions that have proved fruitful in the classroom or other domains to academic-support programming is a promising area for future research.

**Critical Research Question 2: How does the institutional positioning of academic support programming relate to usage and outcomes for students from different identity groups?**

**Subquestion a: Does placement of services in community-specific environments (e.g., within multicultural houses) result in greater usage, or more desirable outcomes?**

Research suggests that in general, students whose identities are marginalized are less willing than others to seek help. Asking for help can feel like exposing oneself as academically inferior, which can pose a threat to one’s self-esteem (Karabenick & Gonida, 2018; Karabenick & Knapp, 1991; Pokorny & Pickford, 2010; A. M. Ryan & Pintrich, 1997; Sánchez Rosas & Pérez, 2015). Students with lower levels of prior academic achievement tend to be, ironically, less likely to ask for help than those with greater academic preparation (Ryan et al., 2001). Students who may already feel marginalized in the academic environment — for instance, students from marginalized racial or ethnic groups, low-income students, and first-generation college/university students (Sánchez Rosas & Pérez, 2015) —
are often especially concerned about the stigma of help-seeking. (See the Psychosocial section for
detail on this.) Particularly in more selective institutions, stigma can be intertwined with impostor
phenomenon (often referred to as “impostor syndrome,” which is not favored because it
pathologizes the experience), in which students harbor a worry that they might not, after all, merit
the place they have earned in the institution (Bertelsen et al., 2013; Fischer, 2010; Lee & Kramer,
2013; Patel et al., 2015; Sonnak & Towell, 2001).

One approach that a number of institutions have taken to reducing this sense of stigma, and
consequent avoidance of help-seeking, is to create support spaces specifically for particular identity
groups. Multicultural student centers and LGBTQ+ resource centers, for instance, can provide an
anchor for many students who might otherwise feel marginalized on campus. Moreover, offering
services in locations that are convenient for students is one of the common strategies used to
increase usage (Rennar-Potacco & DeYoung, 2007). However, the degree to which placement of
academic-support programming within these spaces will impact outcomes remains unknown.

**Critical Research Question 3: How does intergroup diversity play out in group learning situations
within academic support environments?**

*Subquestion a:* Does the identity of a tutor/coach/facilitator impact outcomes for different
groups of students (e.g., based on race, gender, prior achievement, etc.)?

*Subquestion b:* How does the demographic makeup of a learning group impact outcomes for
different students?

There is contradictory evidence on the effect of group diversity on the achievements of
students from different populations who are working in pairs or groups. In some cases,
heterogeneous groups achieve positive group dynamics (Kimmel & Volet, 2010) and greater learning
gains than homogenous groups (Micari et al., 2016; Saleh et al., 2005). This would seem to contradict
previous findings that homogeneous study groups produce higher levels of motivation (Robbins &
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Fredendall, 2001), greater learning gains (Gijlers & De Jong, 2005) and fewer conflicts (Ledwith & Asgill, 1998). There is also evidence that majority-group students tend to dominate discussion in mixed-ethnicity groups (Wilkinson & Fung, 2002) and that male students tend to participate more actively than females (Micari & Pazos, 2014; Underwood et al., 2000). Additionally, studies suggest that role models who are members of underrepresented or marginalized groups create a welcoming academic culture for students who identify similarly (Blake-Beard et al., 2011; Cole et al., 1999; Marx et al., 2009). Likewise, female mentors have a positive impact on female students in the STEM disciplines (Stout et al., 2011). More research is needed to better understand the impact of intergroup characteristics on student experience and performance in academic support settings.
Research Area 3: Psychosocial Factors in STEM Academic Support

Psychosocial factors — those related to the interplay between one’s own psychology and the social environment — play a critical role in academic success. These factors play a role in constructing one’s academic self-concept, or the general sense one has of oneself within the learning environment (Marsh & Martin, 2011), and some of them, such as stereotype threat, bear a particular relationship to one’s feelings of inclusion within the academic environment. We elaborate below on several psychosocial factors particularly relevant in the STEM academic-support arena.

Self-efficacy is the belief that one has the ability to perform and succeed at a given task (Bandura, 1982, 1997). Self-efficacy has repeatedly been found to predict outcomes such as academic success, student retention, and GPA (Bandura, 1997; Bouffard-Bouchard et al., 1991; Lane et al., 2004; Linnenbrink & Pintrich, 2003; Pajares & Miller, 1994; Zimmerman & Bandura, 1994). Self-efficacy is understood to stem from four key sources: one’s own mastery experiences (successes), vicarious experiences of the success of others who are similar to us (such as mentors or peers), persuasion, and psychological states or mood (van Dinther et al., 2011). Interventions designed to improve students’ self-efficacy, and in turn their academic outcomes, typically incorporate these factors. For example, instruction on study strategies, which presumably allows students to experience a greater sense of mastery (Bergey et al., 2019; Graham et al., 2019), and engaging learners in guided instruction designed to enable mastery experiences, encouragement, and vicarious success (Betz & Schifano, 2000), have both been shown to promote self-efficacy for the relevant domain.

Help-seeking is a critical learning activity. A substantial body of literature has examined factors relating to students’ help-seeking behaviors, such as who seeks help, to what extent, and why, with considerable evidence for the positive impact of help-seeking on academic performance (R. Micari, M., Sriram, J., Getty, S., McCune, C., Rice, H., & White, S. (2021). Supporting Student Learning Outside the Classroom: A Research Agenda for STEM Academic Support at the Undergraduate Level. (Working paper.)
Hodges & White Jr, 2001; Karabenick, 2012; Karabenick & Gonida, 2018; Karabenick & Knapp, 1991; Kitsantas, 2002; Newman, 2000; J. D. Williams & Takaku, 2011). The tendency to seek help or to avoid seeking help is related to students’ self-perceptions, academic and social goals, stereotype threat, and level of confidence and self-esteem (Collins & Sims, 2006; Ryan et al., 2001). For example, students might avoid seeking help due to a desire for autonomy, or due to the belief that seeking help would threaten their self-perception of competence. These factors can also be related to the classroom context; for example, learning environments that emphasize self-improvement, as compared to an emphasis on relative ability, have been shown to promote help-seeking behaviors (Ryan et al., 1998). Students who feel concerned that seeking help may threaten their identity in some way, including those who experience stereotype threat, are also less likely to seek academic help (Cabrera et al., 2016; Karabenick & Knapp, 1991; Patel et al., 2015; Rodriguez et al., 2016; Winograd & Rust, 2014). This is closely related to sense of belonging in the academic environment: Less sense of belonging has been linked to lower likelihood of engaging with teachers and peers about class content (Hurtado et al., 2011; Pyne & Means, 2013; Schwitzer et al., 1999). Generally, the research suggests that students with marginalized identities, who are more likely to lack a sense of belonging in academic environments, may tend to engage in lower levels of academic help-seeking than other students do (Cabrera et al., 2016), and some research has shown that first-generation college students are less likely than others to seek academic help or engage with teachers (Collier & Morgan, 2008; Jenkins et al., 2009; Rodriguez et al., 2016). Gender, too, has been identified in the research as impacting academic help-seeking behaviors. For example, men who identify strongly with masculine norms are less likely to seek help than are those who identify less strongly with those norms (Wimer & Levant, 2011).

**Impostor phenomenon** (Clance & Imes, 1978) — we avoid the term *imposter syndrome*, which suggests a pathology (Feenstra et al., 2020) — occurs when an individual maintains a strong belief...
that they are not sufficiently intelligent or talented to belong in a given environment. Imposter phenomenon has been observed in undergraduate and graduate students, students of color, and first-generation college students, as well as in the workforce, especially in women in STEM (Gardner & Holley, 2011; Stebleton et al., 2012). Imposter phenomenon has been positively correlated with anxiety, depression, psychological distress, and marginalized social identity (Clance & Imes, 1978; Cokley et al., 2013; Harvey & Katz, 1985; Henning et al., 1998). Imposter phenomenon undermines self-esteem and sense of belonging, which in turn may negatively affect academic success (Cozarelli & Major, 1990; Walton & Cohen, 2011). Interventions targeting a sense of belonging, which can reduce the strength of the imposter phenomenon, have been shown to improve GPA and student retention, in particular for students with marginalized identities (Yeager & Walton, 2011). These effects have been observed with even very brief interventions (e.g., Walton & Cohen, 2011), supporting the possibility that small changes could have significant impact. These interventions include having students affirm their values related to attending college (e.g., Miyake et al., 2010) and normalizing experiences of social adversity during the college transition (Stephens et al., 2014; Walton & Cohen, 2011).

Stereotype threat (Steele, 1997) occurs when awareness of a stereotype about a social group with which one identifies negatively affects one’s performance on an important task. A substantial body of literature has demonstrated the negative impact of stereotype threat on academic performance, as well as performance in a variety of other domains (Beasley & Fischer, 2012; Bell et al., 2003; Hess et al., 2003; K. E. Ryan & Ryan, 2005; Stone et al., 2012). In addition, there is substantial evidence that stereotype threat has both short-term (e.g., exam performance) and long-term (e.g., career choice) effects (Woodcock et al., 2012). Studies have shown that stereotype threat most dramatically impacts individuals high in ability and those who strongly identify with the relevant domain (Aronson et al., 1999; Osborne & Walker, 2006). Recommended strategies to reduce
stereotype threat include explicitly labeling tasks to indicate that there are no stereotypical differences in performance (Kray et al., 2001), providing role models that negate the stereotype (Marx & Roman, 2002), teaching about stereotype threat directly (Johns et al., 2005), affirmation of one’s values (Jordt et al., 2017) and encouraging self-affirmation (Martens et al., 2006b), mentorship (Stout et al., 2011), having an instructor who shares the student’s identity or who is perceived to be culturally aware and unbiased (Brown & Dobbins, 2004), and instruction on the malleability of intelligence (Good et al., 2003). Studies have shown that such approaches reduce stereotype threat across several demographic variables, such as gender (Marx & Roman, 2002; McGlone & Aronson, 2006; Rosenthal & Crisp, 2006) and race (Alter et al., 2010; Good et al., 2003). However, much of this research comes from laboratory or classroom settings rather than academic-support settings (Shapiro et al., 2013).

Attributional style (Seligman et al., 1979) refers to the ways in which individuals tend to explain events in their own lives, particularly success or failure experiences. Attribution theory (Weiner, 1985, 2010) identifies four dimensions of the attributions people make for events they experience: internal vs. external; controllable vs. uncontrollable; stable or enduring vs. unstable; and global, or generalizable across events, vs. particular. Research into the impact of attributional style on academic achievement has produced contradictory results. There is some evidence, however, that individual student characteristics may confound the effects of attributional style, perhaps explaining some of these mixed research results. For instance, Gibb et al. (2002) found that incoming test scores confounded the relationship between attributional style and academic performance: students with high SAT scores who made internal or stable attributions for negative events – which ordinarily would be expected to produce negative outcomes – had higher GPAs than students with low SAT scores who made those same attributions.
Mindset, or implicit theory of intelligence (Dweck, 2006; Dweck et al., 1993) is a related construct. Mindset refers to a person’s tendency to view intelligence as malleable or as fixed. A good deal of research provides evidence that a growth mindset (i.e., a malleable view of intelligence) is predictive of academic success (Aronson et al., 2002; Claro et al., 2016; Dweck, 2006; Spitzer & Aronson, 2015; Yeager & Walton, 2011). A growth mindset is thought to reduce limiting thoughts and improve motivation. A number of interventions that teach growth mindset have been successful in improving academic performance as well as factors such as achievement goals (DeBacker et al., 2018) and cognitive load (Xu et al., 2020). In some cases (e.g., Aronson et al., 2002), these effects have been particularly observed among students with marginalized identities. However, the evidence for the impact of growth mindset has been mixed. A 2018 meta-analysis (Sisk et al., 2018) reported only weak associations between mindset and achievement. Further, some scholars have voiced concern that the growth mindset concept has been widely adopted in practice prematurely, and Dweck and others have stated that its use in practice has not always aligned with practices supported by the research (Denworth, 2019; Dweck, 2015). Both growth mindset and the related concept of “grit” — a tendency to persevere and maintain passion for one’s goals through challenges (Duckworth, 2016; Duckworth et al., 2007) — have received criticism for ignoring the institutional and structural factors that can impede success for students with marginalized identities (Denby, 2016; Kohn, 2015; Mehta, 2015; Ris, 2015).

Affective experience is an increasing concern across college campuses, as college students are increasingly reporting struggles with mental health, such as depression and anxiety, and this was true even before the sharp increase seen during the COVID-19 pandemic (Center for Collegiate Mental Health, 2021). University mental health supports are often stretched very thin in attempting to meet student demand (LeViness et al., 2019; Novotney, 2014), and students experiencing mental health struggles do not always seek out counseling (Masuda & Boone, 2011). Mental health struggles both
stem from and feed into academic difficulties, and are correlated with lower academic achievement and retention rates (Kitzrow, 2003; Thompson et al., 2013). Aspects of the affective realm which are especially relevant to academics include test anxiety, perfectionism-related stress, and feelings of imposterism and lack of belonging.

*Critical Research Question 1: How can institutions most effectively encourage students’ help-seeking and use of academic support services?*

- Subquestion a: What messages are most effective in encouraging help-seeking, and how does that effectiveness differ across settings and student subgroups?

- Subquestion b: What is the impact of targeted outreach to students who are earning low grades in their courses?

There is a large body of research examining the use of persuasion in messaging, with numerous studies investigating the impacts of various approaches to messaging on people’s inclination to seek help for mental health and health-related problems (Christopher et al., 2006; Joyce & Weibelzahl, 2011; Siegel et al., 2015; Suka et al., 2020). Messaging can make a difference in people’s behavior, and getting the message right should be particularly important for encouraging students who are more reluctant to seek help to take part in academic-support programming. However, there is little research specifically addressing methods of persuasion for academic help-seeking (notable exceptions include Covarrubias et al., 2019; Deacon et al., 2017). Using a psychosocial lens to investigate messaging could be fruitful groundwork for future research. For example, what approaches to messaging about academic support services can both persuade students to seek help and encourage growth-oriented self-assessments as students encounter academic challenges? Do marketing messages that emphasize correction promote deficit thinking — assuming that the student is “deficient” and needs to be “fixed” — whereas messages that emphasize the difficulty of the task might normalize and promote the struggle inherent to productive
learning? Investigation into the impact of type, tone, and content of a message, as well as the source and medium of the message (e.g., flyers, social media, classroom announcements, email from faculty, communication with peers or parents), could provide insight into the messaging approaches most likely to result in use of support services and success with those services, as well as for whom particular messages work best. Impact may vary, for example, across demographic groups, for students with particular personality traits, or for students with learning disabilities. In particular, targeted messaging or services to students who are struggling academically (e.g., students who are at risk for failing courses or probation) might have a beneficial effect. Or, they could trigger stereotype threat, prompt defensive reactions, or further harm students’ self-esteem and motivation. Research into these relationships would provide guidance for faculty, advisors, and learning centers hoping to reach the most at-risk students.

**Critical Research Question 2:** Within an academic-support environment, what curricular and programmatic approaches most effectively promote inclusion, specifically through increased sense of belongingness, reduced imposter phenomenon, and/or reduced impact of stereotype threat?

Students whose identities are marginalized, or are underrepresented within their disciplines, are particularly susceptible to a reduced sense of belonging, to imposter phenomenon, and to the impact of stereotype threat — all of which can have a negative effect on learning, performance, and retention in STEM. Although effectiveness of interventions targeting these factors has been examined (Alter et al., 2010; Cisco, 2020; Cohen et al., 2006; Walton & Cohen, 2011; Zanchetta et al., 2020), the use and impact of such interventions within an academic-support setting has been far less researched. Studies incorporating interventions such as those described in the section above (e.g., values affirmation) into support programming would provide guidelines for student learning centers and other support providers in developing programs and services that both welcome students and extend broader institutional efforts to provide inclusive learning environments.
**Critical Research Question 3:** What curricular and programmatic approaches within STEM academic-support services positively impact academic self-concept, specifically in terms of increasing self-efficacy, encouraging productive attributions and mindset orientations, and/or improving the affective academic experience for students?

A number of studies have examined the effectiveness of psychosocial interventions designed to impact outcomes such as growth mindset, self-efficacy, and academic anxiety (Bartsch et al., 2012; Broda et al., 2018; DeBacker et al., 2018; Hulleman & Harackiewicz, 2009; T. F. Smith & Capuzzi, 2019; Yeager & Walton, 2011). However, these have generally been situated in laboratory or classroom settings. Research is needed on the psychosocial impact of both targeted psychosocial interventions within support programming to promote productive psychosocial approaches, as well as of the differential impact of varied programming approaches (e.g., peer-group experiences vs. one-to-one experiences). For example, how do particular tutoring policies and practices impact sense of belonging or a growth mindset? How does tutors’ use of particular forms of language affect students’ academic help-seeking behavior? And does this differ across students with particular characteristics? How might interventions aimed at metacognition and self-regulation help to improve psychological wellness as well as academic difficulties (Kim & Hodges, 2012; Legg & Locker, 2009)? How does the timing of psychosocial interventions (e.g., during orientation, after midterms, between the first and second semesters, or after the first year) impact both psychosocial and academic outcomes? Is a single-session intervention enough to change a student’s behavior, or are multi-session interventions necessary in order to impact behavior? And finally, are targeted interventions necessary to change behavior or is simply incorporating practices informed by knowledge of psychosocial factors enough to influence student behavior? Complicating this issue is the fact that, as suggested by some researchers (e.g., Yeager & Walton, 2011), the most effective format might differ from institution to institution.

Research Area 4: Metacognition and Self-Regulation in STEM Academic Support

Metacognition and self-regulation are interrelated concepts describing the processes of recognizing and understanding what one knows and does not know, and knowing which steps to take as a result of such recognition and understanding (Flavell, 1979; Newman, 2002). Metacognition is primarily the cognitive act of thinking about thinking. Self-regulation is usually thought of more broadly than metacognition because it involves deciding which academic strategies to use as a result of metacognitive awareness and of assessing one’s strengths and weaknesses in non-cognitive areas. There is a large body of research around metacognition and self-regulation of learning, including the development of multiple scales for each construct. Examples include the Learning and Study Strategies Inventory or LASSI (Weinstein et al., 1987), the Self-Regulated Learning Interview Scale or SRLIS (Zimmerman & Martinez-Pons, 1988; Zimmerman & Pons, 1986), and the Motivated Strategies for Learning Questionnaire or MSLQ (Pintrich, 1991). Metacognition and self-regulation are essential for effective studying and learning (Cook et al., 2013; McGuire, 2015; Schneider & Artelt, 2010; Winne & Hadwin, 2013; Zimmerman, 1989, 2002, 2008). Undergraduate students who make greater use of metacognitive strategies tend to have higher grades (Cook et al., 2013; Hacker et al., 2009; L. C. Hodges et al., 2020; McGuire, 2015; Schleifer & Dull, 2009; Young & Fry, 2008) and other positive academic outcomes (Bol et al., 2016; Gettinger & Seibert, 2002; Kitsantas, 2002; Mega et al., 2014). Self-regulation is also highly correlated with help-seeking behaviors; students who self-regulate well are more likely to seek help when needed (Dunn et al., 2014; P. Pintrich & García, 1993; Zimmerman & Pons, 1986).

On the whole, research indicates that college students often lack awareness of the most beneficial study and metacognitive strategies (Kornell & Bjork, 2008; McCabe, 2018; Roediger III & Karpicke, 2006; Yan et al., 2017). In response, some studies in the past two decades have assessed

interventions to improve students’ metacognition or self-regulated learning skills, with fewer also examining the downstream effects of such interventions on other academic outcomes. Some studies have found that teaching students about study strategies through study skills courses (Burchard & Swerdzewski, 2009; Hofer & Yu, 2003; Tuckman, 2003; Tuckman & Kennedy, 2011), or structured activity and conversation (Lizzio & Wilson, 2013), as well as within course lectures (Cook et al., 2013), predicts increases in course grades and GPA. Many of these studies are targeted toward training students in specific courses (e.g., Cook et al., 2013; Gama, 2004; Kramarski & Mevarech, 2003; Stanton et al., 2019; Teong, 2003; Zhao et al., 2014), whereas some focus on providing general metacognitive skills training (e.g., Dörrenbächer & Perels, 2016; Erskine, 2010; Hoops et al., 2015).

Taken together, these studies suggest that providing training on metacognition and encouraging students to reflect on their own metacognition can improve students’ self-regulation abilities and learning outcomes.

Extensive research in cognitive science has identified specific learning strategies that enhance student learning and retention. Strategies with the clearest evidence of improving learning and retention of knowledge include distributing study sessions, also known as spacing (Kornell & Bjork, 2007); switching between topics while studying, also known as interleaving (Kornell & Bjork, 2008); retrieval practice or testing (Roediger III & Karpicke, 2006; Rowland, 2014); elaboration techniques such as elaborative interrogation (Smith et al., 2010), self-explanation (Wong et al., 2002); dual coding (Fernandes et al., 2018); and preparing to teach others (Dunlosky et al., 2013; Ley et al., 1995; Roediger III & Karpicke, 2006). Calibration, or the ability to accurately gauge one’s own knowledge or ability level, is also considered to be an important metacognitive skill (Alexander, 2013). In general, these strategies align with the “deep learning” approach first described by Marton & Säljö (1976), which has been linked to greater levels of understanding and course achievement (Bunce et al., 2017; Heikkilä & Lonka, 2006; Vermetten et al., 2001). It is important to note that strategies which aid in
memorizing information may not improve long-term retention, conceptual understanding, or the ability to apply knowledge in new contexts. Further, course assessments may or may not require students to demonstrate conceptual understanding and application, and thus may or may not align well with use of higher-level cognitive strategies.

A small survey-based study by (McCabe, 2018) suggested that university learning centers were encouraging students to use some, but not all, research-supported learning strategies. At the same time, there is evidence that students often do not incorporate information they receive about effective study strategies (Bergey et al., 2017). In research examining the strategies actually employed, students report testing themselves on information (Blasiman et al., 2017; Morehead et al., 2016), but also using strategies that have been shown to be less effective, such as highlighting, rereading without engaging the text, and cramming (Hartwig & Dunlosky, 2012). It is likely that many students are unaware that these study strategies are ineffective, in part because study tends to happen in an environment where answers are readily available (e.g., rereading explanations), leading students to experience “illusions of competence” to a greater extent than they would in a testing-style environment where answers are hidden (Karpicke et al., 2009). A number of studies have reported that personality traits of students such as openness to experience and conscientiousness, as well as characteristics such as empathy, are associated with adoption of desirably difficult, effective learning approaches (Arteche et al., 2009; Chamorro-Premuzic et al., 2007; Duff et al., 2004; Swanberg & Martinsen, 2010; Zhang, 2003; c.f. Kokkinos et al., 2015). Moreover, there is clear evidence that teaching approaches and classroom environment impact the learning strategies that students use (Anderman & Patrick, 2012; Baeten et al., 2010; Campbell et al., 2001; Kek & Huijser, 2011; Nijhuis et al., 2005; Vos et al., 2011; Wang et al., 2013). Only very limited research (e.g., Antonelli et al., 2020; S. E. Johnson et al., 2011; Williams et al., 2020) has been conducted on differences in study approach based on demographic factors, or on how factors such as stereotype Micari, M., Sriram, J., Getty, S., McCune, C., Rice, H., & White, S. (2021). Supporting Student Learning Outside the Classroom: A Research Agenda for STEM Academic Support at the Undergraduate Level. (Working paper.)
threat, impostor phenomenon, or a lack of sense of belongingness — all of which disproportionately impact students with marginalized identities — might influence students’ adoption of particular study strategies.

**Critical Research Question 1: What intervention approaches within academic-support settings lead to students’ adoption of productive metacognitive strategies, in both the short and long term?**

*Subquestion a: How does the effectiveness of such approaches differ among different populations of students (e.g., based on social identities, pre-college students, degree of difficulty experienced in a course, etc.)?*

Various approaches to teaching metacognition and self-regulation have been described in the literature, and as noted earlier, some studies have found such training to have positive effects. However, much less is known about the particular characteristics of training — the way training is framed, the nature of the activities used, its length and structure, etc. — that make it more or less effective in promoting behavior change in students. It is unclear, for instance, whether students would be more likely to put metacognitive skills to use when these are learned within the context of a disciplinary course (e.g., taught by faculty as a unit within a chemistry class), within a program offered by staff at a college learning center, or within programming conducted by trained peers. Metacognitive training can also take different forms, for example stand-alone workshops on study skills, or as a full credit-bearing course. We know of no study that directly compares the efficacy of different instructor types or structural formats. There is also room for research on the efficacy of various approaches to virtual metacognition training: Several studies (e.g., Cardinale & Johnson, 2017; Pryjmachuk et al., 2012; Tuckman, 2002) have found positive effects of online metacognitive interventions, but the optimal structure for such interventions is not clear.

The question of for whom particular interventional approaches are most effective also remains unanswered. How particular approaches to metacognitive training impact students with
marginalized identities, first-generation college students, and students with learning disabilities is of particular concern. Also relevant here are the training setting (e.g., in a learning center vs. within an affinity-group setting) and the ways in which the training is offered and promoted (e.g., offered to all vs. targeted, presented as help vs. part of the standard college academic experience).

Intervention effectiveness has generally been measured in one of two ways: 1) self-report measures of study or metacognitive skills, or 2) improvements in grades. For example, one might look for an improvement across pre- and post-tests on a metacognitive skills test such as the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) or a study skills test such as the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1993). One drawback of self-report is that, by and large, students do not have particularly accurate insight into their study or metacognitive skill use (Miller & Geraci, 2011). Self-report also introduces the risk of memory failure and social desirability bias. Therefore, behavioral measures are also necessary to provide converging evidence of improvements. Further, once an intervention has been shown to be effective, it would be useful to understand whether those improvements are also observed in concurrently enrolled classes, as well as how long the improvements persist.

Most interventions in the research literature incorporate multiple components. In other words, students might be trained to incorporate multiple study strategies such as retrieval practice, spacing, and elaboration, or multiple metacognitive strategies that address planning, monitoring, and evaluating, all in a single study. Although this increases the potential of finding an effect, it muddies the water in terms of determining which strategies are most effective. Some meta-analyses and reviews provide insight into this (e.g., Dunlosky et al., 2013; Hattie, 2011), for example suggesting that training in the planning components of metacognition are more effective than monitoring and evaluating. However, few controlled studies (e.g., Saenz et al., 2019) directly
compare the effectiveness of different strategies, and those that do are limited to the laboratory.

More field experiments and carefully controlled studies are needed to better understand the effectiveness of approaches to training in metacognition.

**Critical Research Question 2: What is the ideal timing of metacognitive and self-regulation-oriented interventions?**

There is little to no research on the ideal timing for academic-support interventions in STEM. However, the timing of interventions more broadly has been shown in the research to be a critical factor in their success (Cortes et al., 2019; Fernandez et al., 2015). In the term-based academic environment, in which students have just a matter of weeks to learn and then be assessed on course material, timing might be especially important, and this may be complicated by the potential reluctance of students to attend to information about useful study strategies until they are struggling in courses. Motivation and receptivity to metacognitive support may wax and wane over the course of a term, for instance increasing after students receive their first midterm grades, or decreasing in periods of particular stress, such as the pre-finals week. Research investigating the relative impact of interventions timed at different points in students’ college paths could support institutional resource planning, enabling decision-makers to provide students metacognitive training at the points when it is most likely to make a difference.

**Critical Research Question 3: Under what circumstances does metacognitive training transfer to other domains or environments?**

Research on the impact of metacognition training within discipline-based courses (e.g., general chemistry) has proliferated in the past decade, with documented positive learning effects through teaching Bloom’s taxonomy, the PLRS study cycle (Cook et al., 2013), reflection assistants (Gama, 2004), and the like. However, there has been very little investigation into whether these...
skills, once learned, are transferable outside of the context of the course in which they are taught. As with critical thinking, there is also debate about whether metacognitive skills can be taught as general skills, independent of domain content, or whether they must be taught embedded within a subject-specific course (Gunn et al., 2011; Jones, 2007; McCardle & Hadwin, 2015; Moore, 2004; van der Stel & Veenman, 2010; Veenman & Verheij, 2003). It may be that particular approaches to metacognitive training are more or less likely to “stick” with students as they move through other courses. Research investigating the features of course-based metacognitive instruction that produce greater transfer to other settings, as well as the longevity of the effects and for which students the impact is strongest, would improve both quality and efficiency of such training modules.

**Critical Research Question 4: What is the relationship between students’ psychological states and self-regulation of learning?**

**Subquestion a:** How can psychosocial interventions best be leveraged within the STEM academic-support context to encourage self-regulation of learning?

A large body of research exists on the relationship between psychological states and learning (Linnenbrink, 2007), with substantial evidence for the deleterious effect of psychological stress on cognition (Calvo & Gutiérrez-García, 2016; Marin et al., 2011; Sandi, 2013). More limited research has established a connection between psychological states and students’ use of metacognitive and self-regulation strategies. For instance, there are established links between anxiety and approach to study (Cipra & Müller-Hilke, 2019; Warr & Downing, 2000), between stereotype threat and metacognition (Fourquet et al., 2020), and between stereotype threat and self-regulation (Rydell & Boucher, 2017). These connections are thought to occur because of the additional tax on executive functioning processes caused by psychological stressors, although the relationship between these factors is complex and may be moderated by a number of other variables (Plieger & Reuter, 2020). Additional research on the relationship between psychological states and both metacognition and executive
functioning is needed. Moreover, only very limited research has evaluated the impact of psychosocial interventions (Yeager & Walton, 2011; see Research Area 3) on metacognition and academic self-regulation (e.g., Tajoldini et al., 2018); additional studies would enable more targeted and effective academic-support programming for students experiencing psychosocial distress.
Research Area 5: Institutional Factors and Partnerships in STEM Academic Support

Higher education institutions are by and large organized vertically, and comprise multiple divisions — schools, academic departments, administrative units — that operate with relative autonomy (Dufault, 2017; Keeling et al., 2007; Tony & Paul, 2001). Moreover, as higher education institutions have evolved, changes such as increased managerial specialization and greater need for structured assessment have created tensions between academic faculty and managerial staff, as well as between faculty and university administrations (Stensaker, 2018). A lack of shared articulation of goals across levels of a university — departmental, divisional, and institutional — further impairs joint decision-making and outcomes assessment (Rizvi & Jacobsen, 2018). Taken together, these features of university life can inhibit cross-fertilization of ideas and cross-divisional collaboration on initiatives, with collaboration sometimes viewed as a potential threat to autonomy and even quality (Kezar, 2006). This can make it difficult for disparate units to successfully coordinate their operations. Tighter “coupling” of otherwise distinct units, and ongoing support for these relationships, may enable more productive collaborations and promote student success (Ewell & Wellman, 2007; Hearn, 2006; Weick, 1976).

The academic support function within a university might be especially sensitive to these potential organizational weaknesses, given the unusual position it takes in many institutions, straddling the academic and student-services missions of the institution. Yet it is frequently situated in such a way that critical relationships remain elusive, with a potential negative impact on program effectiveness. For example, without support from student affairs operations, a STEM tutoring center operating within an academic department may face challenges in publicizing services, or even finding space for programming. How and where academic support is located within an institution, both organizationally and physically, will have an impact on its orientation, reputation, approach to
programming, inter-unit relationships, and, ultimately, on the outcomes of student services. Few studies have systematically examined these issues; such examination would help university administrators make decisions about the structural organization of support programming (Patton et al., 2006; Tinto, 2006).

**Critical Research Question 1:** In what ways does the organization of an academic-support unit (or program) on impact key outcomes?

**Subquestion a:** What is the impact of the organizational position and reporting line of the academic-support unit (or program) on the unit’s operations and student outcomes?

**Subquestion b:** What is the impact of the physical location of an academic support unit (or program) on

- student usage, both generally and by various student populations, e.g., students with disabilities, students with marginalized identities, international students?
- perceptions of academic support among students and faculty?

Academic support in U.S. colleges and universities varies in its structure, with a number of different models existing across institutions (Toms, 2014; Truschel & Reedy, 2009). It may take the form of a centralized function — for instance, where a single entity is responsible for coordination, marketing, scheduling, training of tutors, and so forth across various disciplines — or it may be offered through individual STEM departments with or without coordination among them (Arendale, 2010; Dufault, 2017). The majority of academic support functions are affiliated with academic affairs departments, with a smaller proportion associated with a student affairs office or housed within a specific academic department or school (D. R. Arendale, 2010; Boylan, 2002; Toms, 2014). In general, centralizing academic support services within the functional organization of an institution, as well as centralizing them within a physical location, is viewed as more desirable than dispersed offerings and is assumed to more effectively promote student success (Cambridge, 2000; Engle & O’Brien, 2007; Engstrom & Tinto, 2000; Hossler et al., 2009; McGuire & Williams, 2002; Schmidt & Kaufman, 2005).
Centralized organization, as compared to dispersed organization, could reduce barriers to accessing services, especially for students who are more reluctant to seek help; should allow for multiple overlapping, learning communities that already exist (Marcy & Guskin, 2003); and may help consolidate resources (Balk, 2012; Kezar, 2006; Kezar et al., 2015; Toms, 2014).

Reporting lines also influence financial models. The division or unit within which the support function resides will impact budget allocations, access to institutional decision-makers, operational and philosophical approach, and ability to innovate. Student learning centers are often included in university-wide budgets as a line item, but support can also come from departments, student government, and private donations (Toms, 2014). Some academic-support units are allocated independent budgets, while others draw funds from the budgets of the entities they fall under, as in an academic department with some allocation of funds for tutoring (Toms, 2014). Funding models drive availability of resources for academic support, and in turn the quality and availability of support services. For example, when institutions allocate funds to schools and departments based on the number of students enrolled, they risk uneven allocation of academic support across disciplines when the academic support functions sit within the departments themselves (Ehrenberg, 2002). Of note, most centers do not charge for tutoring services (Truschel & Reedy, 2009); it is generally assumed that free services (or fees as part of tuition), rather than pay-for-service models, are correlated with higher attendance, especially among students with fewer resources.

Research is needed to guide institutional investment and decision-making around the organizational location, structure, and reporting lines of academic-support functions. For instance, how might a support unit situated within a student affairs division differ in its approach, outreach, and student impact from a unit which sits within a department or an academic affairs unit? How does the reporting relationship of a unit impact its financial flexibility and ability to innovate, its reputation among key stakeholders, including students, and its reach?

When the academic support function takes the form of a unit or center, its physical location on campus and the material resources it has at its disposal are part of what gives it personality and may or may not define it as an accessible and comfortable space for students. Such entities are often located within a larger student center, a library, or an academic building complex. Some do not have a designated space for programming but rather utilize classrooms or utilize residential spaces (Toms, 2014). The location of support services sends messages about their value and about those who utilize those services, and should bear some relationship to student usage. For example, an inviting student center might create a sense of normalcy around help-seeking, in contrast to visiting a dedicated tutoring space within a STEM department, which might cause students to worry that they would be viewed as deficient if seen accessing services there. Convenience of location would also be expected to impact usage (Rennar-Potacco & DeYoung, 2007), as might co-location of services. For example, the learning commons model — a large, central space housing multiple learning support functions — has in some instances demonstrated increased student attendance (Berkopes & Abshire, 2016; Davis & Sumara, 2008; Davis, 2009). For students with marginalized identities, services located within a “counterspace” (Ong et al., 2018) — a space which creates a welcoming, inclusive climate, such as a multicultural house, or an affinity-linked student organization space — might be expected to increase usage, and to produce a greater sense of belongingness in STEM and better overall student outcomes (Chen et al., 2020; Dika & D’Amico, 2016; Ong et al., 2018). Research is needed to guide institutional decision-making about where to situate STEM learning support services, in terms of proximity to other buildings or offices frequented by students, co-location with other support or academic services, and location as it relates to social identity.
Critical Research Question 2: What is the impact of the quality of the academic support unit’s relationships with key campus partners, including faculty, on students’ perceptions and use of services?

Academic support units (or programs) typically provide support for faculty-taught courses, making faculty buy-in critical to student engagement. While some academic support programs are led by course faculty, most support units are overseen by full-time professional staff dedicated entirely to the learning center. Additionally, most units use undergraduate peers or graduate students, rather than faculty members, to support students directly (Toms, 2014).

Faculty may provide valuable input into decisions about program type, structure, and content, as well as tutor recruitment and training, and may also provide student referrals. Faculty also play a vital role in students’ decisions to seek academic help. Encouragement and normalization of academic help-seeking is critical to student help-seeking behavior, given that many students — especially those who may benefit most — avoid seeking academic help for a variety of reasons, including stigma, fear of consequences, and belief in self-reliance (Karabenick, 2003; Patel et al., 2015; Ryan et al., 2001). Faculty, often more than others within a university, can influence students’ help-seeking behaviors (Micari & Calkins, 2019). Thus, building relationships with faculty would seem to be critical to connecting and publicizing services to students, as well as optimizing services. The existence of an advisory board that includes faculty, and the manner in which an advisory board is used, might also be expected to impact key relationships and potentially influence access to funding and other resources. However, institutional pressures and reward structures may not encourage faculty to expend energy on supporting student development beyond their own course. Indeed, some have suggested a need for a cultural shift to reward faculty to participate in advising, broadly speaking (Dillon & Fisher, 2000; Karr-Lilienthal et al., 2013; Levy & Polnariev, 2016). Faculty may also be reluctant to send students to tutoring or other academic support that operates independently of
their own courses, out of concern that material will be taught incorrectly or inconsistently with their approach (Rudland & Rennie, 2014).

Other student-facing campus partners, such as student affairs units, libraries, residential life departments, and multicultural student support units, can play a critical role in disseminating messages and influencing student attitudes and behaviors around academic help-seeking. Academic support units typically rely on such partners to advertise programming, refer students, and encourage usage. They also sometimes provide physical spaces for support activities (Dufault, 2017; Truschel & Reedy, 2009). Because these partner units often hold sway with large segments of the student population, the quality of the relationship between these campus partners and an academic support unit (or program) would be expected to impact students’ impressions of academic support and their willingness to utilize services. Research into the relationship between inter-unit partnership models and student perceptions, usage, and outcomes would provide administrators guidance on which kinds of collaborations are most fruitful and how best to nurture those. Particular areas for investigation might include the effectiveness of formal partnership models, the impact of physically situating academic support services with other student support units, the impact of formal and informal messaging about academic support through other student support units, and the impact of academic support services offered within other student-facing units’ spaces.
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Appendix: List of Research Questions

Research Area 1: Structure and Form of STEM Academic Support

Critical Research Question 1: What is the relative impact of various tutoring models on student outcomes? Particularly relevant comparisons include the following: Individual vs. group-based tutoring; appointment-based vs. drop-in tutoring; remote vs. virtual settings; and professional vs. peer tutoring.

Critical Research Question 2: What is the relative impact of various models of academic support across subpopulations of students? For example, how do demographic group, referral status (self-referred vs. referred by advisor), probationary vs. non-probationary status, etc., impact the effectiveness of academic support? In particular, does the impact differ across students who do and do not hold marginalized identities?

Critical Research Question 3: Within group support settings, what impact does group composition, in terms of academic preparedness and demographic characteristics, have on student outcomes?

Critical Research Question 4: How does the nature of interpersonal interactions during an academic-support encounter impact student outcomes?

Subquestion a: What are the characteristics of interpersonal and conversational dynamics within an academic-support encounter that lead to better academic and psychosocial outcomes for students?

Subquestion b: In what ways are the answers to (a) above different in a virtual environment?

Critical Research Question 5: What approaches to training of peer learning leaders (tutors, mentors etc.) are effective in promoting behavioral and attitudinal changes in leaders, in both cognitive and non-cognitive domains?

Subquestion a: Which training activities are most likely to impact leader approach and behavior as related to creating inclusive support environments?

Research Area 2: Identity and Diversity in STEM Academic Support

Critical Research Question 1: What programmatic features of academic support are associated with positive outcomes for students with marginalized or underrepresented identities?

Subquestion a: How do bias, stereotype threat, microaggressions, and racism play out in academic-support environments, and how can they most effectively be countered?

Critical Research Question 2: How does the institutional positioning of academic support programming relate to usage and outcomes for students from different identity groups?
Subquestion a: Does placement of services in community-specific environments (e.g., within multicultural houses) result in greater usage, or more desirable outcomes?

Critical Research Question 3: How does intergroup diversity play out in group learning situations within academic support environments?

Subquestion a: Does the identity of a tutor/coach/facilitator impact outcomes for different groups of students (e.g., based on race, gender, prior achievement, etc.)?

Subquestion b: How does the demographic makeup of a learning group impact outcomes for different students?

Research Area 3: Psychosocial Factors in STEM Academic Support

Critical Research Question 1: How can institutions most effectively encourage students’ help-seeking and use of academic support services?

Subquestion a: What messages are most effective in encouraging help-seeking, and how does that effectiveness differ across settings and student subgroups?

Subquestion b: What is the impact of targeted outreach to students who are earning low grades in their courses?

Critical Research Question 2: Within an academic-support environment, what curricular and programmatic approaches most effectively promote inclusion, specifically through increased sense of belongingness, reduced imposter phenomenon, and/or reduced impact of stereotype threat?

Critical Research Question 3: What curricular and programmatic approaches within STEM academic-support services positively impact academic self-concept, specifically in terms of increasing self-efficacy, encouraging productive attributions and mindset orientations, and/or improving the affective academic experience for students?

Research Area 4: Metacognition and Self-Regulation in STEM Academic Support

Critical Research Question 1: What intervention approaches within academic-support settings lead to students’ adoption of productive metacognitive strategies, in both the short and long term?

Subquestion a: How does the effectiveness of such approaches differ among different populations of students (e.g., based on social identities, pre-college students, degree of difficulty experienced in a course, etc.)?

Critical Research Question 2: What is the ideal timing of metacognitive and self-regulation-oriented interventions?
Critical Research Question 3: Under what circumstances does metacognitive training transfer to other domains or environments?

Critical Research Question 4: What is the relationship between students’ psychological states and self-regulation of learning?

Subquestion a: How can psychosocial interventions best be leveraged within the STEM academic-support context to encourage self-regulation of learning?

Research Area 5: Institutional Factors and Partnerships in STEM Academic Support

Critical Research Question 1: In what ways does the organization of an academic-support unit (or program) on impact key outcomes?

Subquestion a: What is the impact of the organizational position and reporting line of the academic-support unit (or program) on the unit’s operations and student outcomes?

Subquestion b: What is the impact of the physical location of an academic support unit (or program) on

- student usage, both generally and by various student populations, e.g., students with disabilities, students with marginalized identities, international students?
- perceptions of academic support among students and faculty?

Critical Research Question 2: What is the impact of the quality of the academic support unit’s relationships with key campus partners, including faculty, on students’ perceptions and use of services?