Uncovering the Complexity of STEM Faculty Perceptions About Successful Students, and Their Teaching Strategies that Support Them

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Abstract

Multiple factors are known to influence student success in higher education. Barriers to postsecondary success for underrepresented STEM students are numerous and well documented. We detail an exploratory study of STEM faculty notions of successful students and the instructional practices they employ to cultivate student success. We use a conceptual framework of educators' perceptions, teaching practices, and student engagement to analyze faculty's perceptions of their students that may inform and influence their teaching practices. This framework also allowed us to uncover potentially unknown and unintended perceptions, practices, and structures that may implicate larger social structures that result in inequities experienced by many individuals in STEM education. We found faculty perceive a range of characteristics and factors indicative and predictive of student success. Faculty also described a wide range of instructional strategies they perceived as effective. We offer insights into STEM faculty practices and expectations that assume and encourage groups traditionally successful in STEM while also highlighting implicit and hidden faculty expectations that may position women, racial/ethnic, and other underrepresented groups as unsuccessful in STEM. This paper adds to the limited research that explores STEM faculty perceptions of their notions of successful students and the relationship between those perceptions and their teaching practices.

Introduction

Improving Student Success in Higher Education

Multiple factors influence student success in higher education (Kuh, 2003). *Student success* is broadly defined as accomplishing academic goals (e.g., passing exams, classes, earning degrees, developing understanding and applications regarding knowledge). Postsecondary faculty members play a crucial role in students' success in higher education (Endo & Harpel, 1982; Umbach & Wawrzynski, 2005). Regular implementation of evidence-based instructional practices (EBIPs), such as active learning strategies, problem-based activities, and group work, has shown to be critical to the success and persistence of students in STEM (science, technology, engineering, and mathematics) disciplines (Austin, 2011; Freeman et al., 2014). STEM courses with active learning-based activity designs correlate with higher rates of students' success than traditional lecture-based methods (Haak et al., 2011). Other research has found that EBIPs afford additional benefits for STEM students from disadvantaged and underserved backgrounds and female students in male-dominated fields (Haak et al., 2011; Lorenzo et al., 2006).

Yet, research also shows that STEM faculty have not implemented EBIPs improvements to the degree that many have hoped for (Henderson et al., 2011). STEM faculty members' understanding, adoption, and adaptations of EBIPs is still limited and challenging (Bouwma-Gearhart et al., 2018; Dancy et al., 2016; Fisher et al., 2019; Henderson et al., 2011). Reasons for the slow adoption of EBIPs are numerous but include organizational cultural norms, structures, and practices (Hora et al., 2017; Kezar, 2012). We know that faculty typically receive little training and professional development regarding their teaching during typical training as graduate students (Bouwma-Gearhart, 2008; Bouwma-Gearhart et al., 2007; Bouwma-Gearhart et al., 2018). Once they become faculty, institutional policies and procedures motivate them to privilege their research over teaching and teaching-related improvement efforts (Bouwma-Gearhart, 2008; Brownell & Tanner, 2012).

Other barriers to adopting EBIPs are a lack of knowledge around them (Patrick et al., 2016) and professional development opportunities and release time to learn about and plan for them (Bathgate et al., 2019; Borda et al., 2020). Additional barriers to EBIPs implementation included faculty members who felt the need to cover content and perceptions that lecture-based instruction best accomplished that goal (Borda et al., 2020). Bathgate et al. (2019) confirmed that science faculty favor lecturing over many EBIPs, and encounter students' resistance to EBIPs. Brownell & Tanner's (2012) literature review concerning barriers to faculty pedagogical changes has generally confirmed these findings. Although Hora (2015) has sagely cautioned against assuming STEM faculty members' "lecture" is ineffective and not aligned with EBIPs, there seems to be a consensus that STEM faculty may over-rely on lecture as practice and at the expense of implementing more effective teaching practices.

One avenue of research links EBIPs with student *engagement,* itself an indicator and predictor of student success in higher education (Kuh, 2009a; Tinto, 2010). *Engagement,* defined as a student's psychosocial actions and characteristics concerning learning activities, includes their behaviors, emotions, and cognition (Kahu & Nelson, 2018). The link between engagement and student success is well confirmed. Some researchers view engagement as the single most significant predictor of students' academic success, including for underrepresented populations such as women, students of color, and other marginalized groups (Kuh, 2009a; Tinto, 1998). Engagement is often wrapped with a goal of increasing the use of EBIPs by STEM faculty (Bouwma-Gearhart et al., 2018; Koretsky et al., 2016). The ability to foster and support diverse student success via their engagement roots many interventions targeting faculty members' pedagogical improvements (Kahu & Nelson, 2018; Kuh, 2009b).

Such focus may help alleviate the impact of a plethora of barriers that stand in the way of students' success from underserved and underrepresented groups in the STEM disciplines (Pierszalowski, 2019; Pierszalowski et al., 2018). Generally, notions of activities in STEM courses as gender-, ethnicity-, and race-neutral meritocracies lead to unwelcoming cultures that privilege white and male students over others (Blackburn, 2017; Johnson, 2007; Shapiro & Sax, 2011). At the postsecondary course and program level, language and tone in such course syllabi can normalize masculinity and disenfranchise those of other genders. As such, women can perceive STEM courses as competitive and selective, discouraging collaborative work and reinforcing lower confidence in their STEM discipline participation (Shapiro & Sax, 2011).

Women of color may perceive the content presented in their undergraduate courses as decontextualized from their real-world experiences (Johnson, 2007). They can encounter faculty expectations that are not verbalized or not noticeable around student actions that enhance their success, such as asking questions and consulting faculty during their office hours (Johnson, 2007; Shapiro & Sax, 2011). In her extensive literature review in 2019, Pierszalowski confirmed many of these findings. She also identified barriers related to an institutional focus on surface-level strategies that had little impact on underrepresented students' persistence in STEM. These barriers included a lack of faculty incentives to mentor marginalized student groups and faculty perceptions that students lack capacity and competence.

Indeed, barriers to postsecondary success for underrepresented STEM students are numerous and well documented. These include climate and culture, more attributable to organizations of people and their interactions and symbols, and things more indicative of faculty members' teaching—the curriculum they use, their teaching methods, and their syllabi. Overall, active learning-based activities and courses have been shown to correlate with increases in the number of students completing science-related degrees, particularly for first-generation students and those from educationally and economically disadvantaged groups (Haak et al., 2011).

What We Know About the Role of Educators Perceptions Impacting their Teaching Practices

Additional barriers to implementing evidence-based instructional practices, like active learning, are faculty perceptions (i.e., conclusions, judgments, insights, beliefs) about teaching and learning, including their teaching practices and their students' realities. We know faculty hold numerous perceptions about their teaching, and these perceptions impact their classroom actions (Fang, 1996; Padilla & Garritz, 2015). For instance, in a study of 24 STEM faculty engaged in teaching professional development activities, Mataka et al. (2019) found a positive linear relationship between STEM faculty perceptions about educators' role, how students learn, and their ultimate decisions around the content and instructional practices they implemented. Faculty who perceived knowledge as conveyed by faculty experts implemented teacher-centered practices such as lecture-based instruction. Addy et al.'s study (2015) of 25 U.S. postsecondary science education faculty found similar findings. Faculty who viewed themselves as facilitators and guides were more likely to adopt and use learner-centered teaching practices. Perhaps not surprisingly, then, initiatives meant to improve postsecondary STEM education often focus on revisions to faculty perceptions (Bouwma-Gearhart et al., 2016; Gess-Newsome et al., 2003; Henderson et al., 2011; Weber et al., 2013). This goal seems well justified, as much scholarship reports on changes to educator perceptions around teaching and learning in light of professional development opportunities. For instance, Kane et al. (2004) found that when science faculty were encouraged to reflect on their perceptions about teaching, specifically their decision-making processes, analysis of teaching performances, and a critical reflection of their actions, they were more likely to develop and implement EBIPs.

However, improvement initiatives' success relies on accurate reads of faculty members' perceptions about teaching and learning, from which to develop strategies and tactics that may be meaningful (Bouwma-Gearhart & Aster, 2021; Bouwma-Gearhart & Collins, 2015; Bouwma-Gearhart et al., 2018; Mataka et al., 2019). Specifically, limited studies have examined and reported on faculty perspectives of their students and what they think helps to ensure their students' success. In one study, Gandhi-Lee et al. (2015) found that 27 STEM faculty described successful students as having personality traits such as curiosity and a strong work ethic, key academic traits such as problem-solving, and good written and oral communication skills. They also found faculty described successful students as having affective qualities such as positive attitudes and interest in and engagement with STEM issues. On the flip side, faculty also perceived a lack of mathematical knowledge and skills as significant obstacles to students' success. Padilla & Garritz (2015), in a study of ten university STEM faculty, found that faculty perceive their students as mostly passive learners (i.e., not engaged in their learning) and lacking in fundamental skills (e.g., efficient reading or writing skills).

This research is indeed helpful in uncovering faculty perceptions of successful students. However, we need more to confirm and extend these findings, including an investigation of how faculty perceptions may determine how and the degree to which they support student success. Without insight into faculty perceptions of their students, those successful and not, professional development experts and others cannot implement improvement initiatives that attend to the impact of faculty perceptions of students and the subsequent influence on teaching practices. We also know little about how they may reduce, or exacerbate, differences in success across student groups in postsecondary STEM. Achievement gaps and lagging completion rates that persist in some student groups in the STEM disciplines (Haak et al., 2011; Lorenzo et al., 2006) suggest that we need to scrutinize faculty perceptions of students and related teaching practices. Given the inequities that still exist for underrepresented students in postsecondary STEM programs and careers (Shapiro & Sax, 2011; Solomona et al., 2005), we must better uncover the realities of faculty well-positioned to have a significant impact on the success of diverse students. Without understanding this relationship, faculty and their leaders lack the knowledge that is key to implementing practices and structures that may specifically improve student success for underrepresented groups in STEM (Kuh, 2009b; Tinto, 2010).

This paper adds to the limited research that explores STEM faculty perceptions of their notions of successful students and the relationship between those perceptions and their teaching practices. We use a conceptual framework of educators' perceptions, teaching practices, and student engagement to analyze faculty's perceptions of their students that may inform and influence their teaching practices. This framework may also allow us to uncover potentially unknown and unintended perceptions, practices, and structures that may implicate larger social structures, such as race, ethnicity, class, gender, language, and other categories; larger social structures that may involve injustices and inequities experienced by many individuals in STEM education (Varelas et al., 2015).

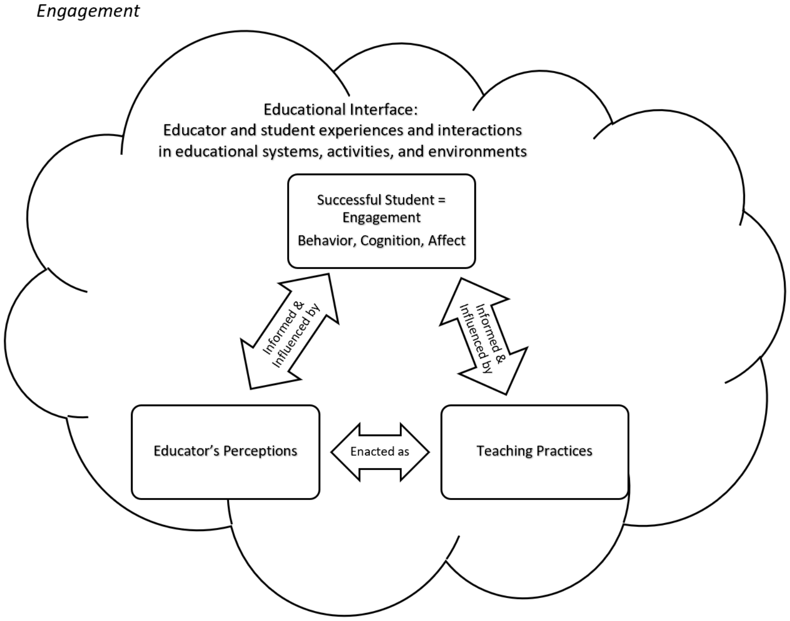
Conceptual Framework

Our conceptual framework includes the notions of *educators' perceptions*, *teaching practices*, and *successful student engagement* situated in larger educational contexts (see Figure 1). The "educational interface," consisting of educator perceptions, teaching practices, and student engagement, occurs and is shaped by complex social systems (Kahu & Nelson, 2018).

Students and educators experience and interact with factors that influence their engagement and success in the educational interface, including a belief in their capacity to perform a given task, their appraisal of their situation as affording or constraining their engagement, and their positive interpersonal interactions with others or the institution. In the educational interface, educators can interact with other individuals and organizations, institutional structures (i.e., policies, curriculum, disciplinary structures), and cultures that can influence their perceptions and teaching practices (Kahu & Nelson, 2018). Teaching and learning environments are such complex systems that educators and students interacting within them may be somewhat blind to all of the influencing structures and practices impacting their perceptions and actions (Varelas et al., 2015).

Figure 1

Conceptual Framework of Educators' Perceptions, Teaching Practices, and Student Engagement



Note. Educational interface and student engagement were interpreted from Kahu (2013) and Kahu & Nelson (2018).

We conceptualize student engagement as three components: *behavior*, *cognition*, and *affect,* central to student success and achievement (Kahu, 2013). Behavioral engagement includes students' outward actions, such as time spent, the effort put forth, participation in activities, and interactions with others. These behaviors can be observed or assumed by educators. For example, doing homework is a behavior that is not always observed but assumed when students produce a result. Cognitive engagement entails students' engagement in learning, acquiring knowledge, problem-solving, and reflections on their learning. For example, a student may be perceived as cognitively engaged if they apply learning to a new problem or situation. Affective engagement is a student's emotional state concerning education- or learning-related activities, such as "enthusiasm" or "interest" in a particular topic. For example, a student may demonstrate affective engagement by expressing excitement at learning new information. As opposed to cognition and affect, students' behavioral engagement may be directly perceivable by others present in the moment. Student behaviors may also be indicative of students' cognitive and affective engagement. Importantly though, any student behavior or indication of cognition or affect can be misinterpreted by others, such as faculty.

Educators' perceptions about teaching and learning, influenced by backgrounds, experiences, and beliefs, play a mediating role in processing information and can serve as mental schemas for constructing and evaluating teaching practices (Jones & Carter, 2007). Educators' perceptions of students' actions and their teaching practices result from beliefs about how students learn and behave (Pajares, 1992). Institutional structures (e.g., disciplines, curriculum, cultural norms, and procedures) influence and reflect faculty perceptions and actions, which impact students (Austin, 2011; Kuh et al., 2008). By association, faculty occupies a unique and powerful space and comprises a large portion of the relationships that students have as part of their lived experiences in educational environments (Austin, 2011). As such, an analysis of faculty perceptions of their students (i.e., student engagement) and how faculty perceive instructional practices as supporting student success can uncover the complex dynamics of teaching and learning environments (Kahu & Nelson, 2018). We use this conceptual framework per its promise in focusing attention on faculty perceptions of successful students' characteristics and the teaching practices they enact that cultivate and support those students' success, all within a larger context.

Methods

Research Questions

The following questions guide our research:

1. How do STEM faculty conceptualize successful students in their disciplines?
2. What instructional strategies do STEM faculty claim to use that they think are effective in cultivating student success in their courses?

Study Context

This qualitative study focuses on STEM faculty from one large university in the United States classified by the Carnegie Classification of Institutions of Higher Education (n.d.) as a *doctoral university with the highest research activity*. Participants were engaged in a comprehensive (campus-wide) STEM education improvement initiative funded by the National Science Foundation, intended to foster evidence-based instructional improvements in large-enrollment, lower-division STEM courses by leveraging the distributed expertise of faculty within and across disciplinary departments. A project research goal was to investigate changing faculty perceptions of teaching and their teaching-related practices in light of the initiative activities. This paper details findings from interview data collected in 2017 around various teaching-related phenomena and perceptions.

Participant Sample

Table 1 shows disciplines, participant pseudonyms, and professional positions for the 19 STEM faculty who participated in this study. Faculty disciplines included physics, biology, chemistry, mathematics, and engineering (chemical, biological, environmental, and mechanical engineering). Nine of the faculty were in tenure-track faculty positions (assistant, associate, and full professor), and ten were in fixed-term faculty positions (instructor and senior instructor). Participants had taught at least one lower-division STEM course in the previous year and were involved in the campus initiative. Race/ethnicity and gender data were not collected in this study, and we do not want to make assumptions about participants' identities. We were further concerned with ensuring anonymity given the sample size, identification of disciplines, and professional positions of a group of faculty from just one university. We use pseudonyms that we perceive as gender-neutral. Potential interviewees were contacted by email to participate in an interview. Nineteen out of twenty-one faculty invitees consented to interviews (90% response rate).

Table 1
List of Disciplines, Participants' Pseudonyms, and Participants' Professional Positions

Discipline	Participant	Professional Position
Physics	Robin	Fixed-Term Faculty
	Jamie	Tenure-Track Faculty
Chemistry	Jordan	Fixed-Term Faculty
	Alex	Fixed-Term Faculty
	Sidney	Fixed-Term Faculty
	Casey	Fixed-Term Faculty
	Tracy	Tenure-Track Faculty
Biology	Jodi	Fixed-Term Faculty
	Peyton	Fixed-Term Faculty
Mathematics	Leslie	Tenure-Track Faculty
	Jackson	Fixed-Term Faculty
	Madison	Fixed-Term Faculty
	Kelly	Fixed-Term Faculty
	Drew	Tenure-Track Faculty
	Shannon	Tenure-Track Faculty
Engineering	Lee	Tenure-Track Faculty
	Bailey	Tenure-Track Faculty
	Logan	Tenure-Track Faculty
	Lynn	Tenure-Track Faculty

Note. N = 19. Tenure-Track Faculty include assistant, associate, & full professors, Fixed-Term Faculty include instructors & senior instructors.

Data Collection and Analysis

An external project evaluator conducted semi-structured interviews approximately one hour in length. While participants commented on a wide array of issues concerning their involvement in the education improvement initiative (see Appendix A for interview protocol), this study focuses on three questions.

1. Describe the characteristics of a successful student in your courses.
2. What kind of instructional strategies do you use that you think are most effective in developing and cultivating successful students?

3. How often do you employ these strategies in your classes?

Interviews were transcribed verbatim and transferred to Dedoose coding software for qualitative analysis. The first author created inductive codes from a first read of the verbatim transcripts, drawing perspectives from interviewees' own words in response to interview questions (Auerbach & Silverstein, 2003). During this first stage, the analyst noted an emerging pattern related to faculty perceptions of student engagement. A second, deductive round of analysis by the first author followed the inductive stage, during which we grouped faculty notions of successful students with Kahu's (2013) concept framework of student engagement. We attempted to stay grounded in faculty descriptions and matching those with definitions of the concepts. During both rounds of coding and analysis, the first analyst created theoretical memos (Montgomery & Bailey, 2007) to provide a record of developing ideas and interconnections.

We used several methods put forth by Creswell (2014, pp. 201–202) to address our findings' trustworthiness. One method we used to ensure the trustworthiness of the analysis was *peer debriefing*. The other authors supported the codes' development and participated in debriefing and data analysis sessions with the first author throughout the data's coding and analysis. The second author also reviewed 20% of the coding to increase reliability and consistency and provide ongoing contributions to the emerging codebook. (See Appendix B for codes.) In both phases, the authors discussed emerging concepts and themes based on their critical reflections on the data, and an ongoing discussion of codes and interpretations addressed (dis)agreements within the data (Auerbach & Silverstein, 2003). At least two interviewees made all the claims we report in this paper. Whenever possible, we included exact numbers of participants in conveying claims. In other instances, we use the following descriptors to provide a range of our findings' prevalence: *a few* means the claim applies to 1-5 participants; *several* means 6-10 participants; *a majority* means 11-15 participants; and *most* means 16-19.

Limitations

We acknowledge the multiple limitations of our research. First, we did not collect observations of faculty practices or student perceptions of their teaching and learning experiences. As such, our data tells a version of STEM faculty perspectives of successful students and their perceptions of instructional strategies that support those students. Nevertheless, we contend our study may still enlighten the field on how faculty descriptions and perceptions may influence interactions with students and instructional practices, particularly the observable and unobservable barriers that underrepresented students may face. Another limitation we acknowledge is that faculty who agreed to be interviewed may not represent most faculty in STEM disciplines. We realize the potential that our findings are representative of those faculty who were most engaged in making improvements via some affiliation with a campus-based improvement initiative and may not fully reflect the larger population of STEM faculty. We also do not explore, per limited sample size, faculty members' perspectives by disciplines. We also acknowledge that disciplinary norms and practices, which we did not investigate, may influence faculty practices and perspectives. Additionally, our research is based on a small sample size, with some claimed voices by a few and, in some cases, two participants. Furthermore, our study took place at one institution with one improvement initiative targeting select STEM disciplines. Our study was exploratory and, as such, does not merit generalizable findings.

Findings

Faculty Conceptions of Successful Students

Faculty conceptualize a range of characteristics that describe successful students in their disciplines, including students' ability to "make progress." Students who were making progress in a course, even if they were not earning an A grade, were considered successful. Faculty also described successful students as engaged students, namely via (a) behavior that occurred within and outside course-related activities, (b) cognition that allowed them acquiring of knowledge, performance in problem-solving, and reflection, and (c) affective means, as enthusiasm, interest, and motivation toward the discipline.

Making Progress With New Understandings Is Key Indicator of Successful Students

Several faculty (6) described successful students as those students who were "making progress" in their courses, which was considered an important indicator of success on par, but not necessarily correlated, with students' grades. Most faculty did not mention grades when talking about making progress as a characteristic of a successful student. Although some faculty equated students earning an "A" grade with their success, they also described successful students as those earning at least a passing grade, which indicated they had learned course content and made progress concerning new knowledge or skills. One faculty described successful students as those who earned an A because the material was familiar and easy for them, compared to other successful students who passed after struggling with the course. Robin (physics) described students in this way:

> *So success varies. It's totally variable. For many of these successful students, the success was that they passed the course, and they were absolutely thrilled, and that might have been a harder challenge and a larger success than the honors kid who got an A because he already knew it and it was already pretty easy.*

Another faculty chuckled as they described a successful student as those who earn an A before describing how learning the content is most important and indicates student success. Jodi (biology) described it in this way:

> *The one that gets the A of course. [CHUCKLE] What I wanted to say is the one that gets it. I feel like there are students who don't get to the point where they're going to get an A in my class, but they're still successful students in that they start to see that what we're doing in the class is not about them getting an A, but it's actually about them learning how to do biology and what biology looks like.*

Another faculty was hesitant to say grades are an indicator of student success, recognizing that students come from different backgrounds and progress at different rates depending on their larger circumstances. Lynn (engineering) said:

> *I hesitate to put a GPA [grade point average] on a successful student because that's really difficult. Every student has a different background. I won't put a number on it, but I will say a student that is progressing at the rate that they almost should be [is successful].*

Another faculty described students making progress as measured by attaining a degree and, ultimately, a productive discipline-based career. Alex (chemistry) holistically described successful students as:

> *I'd like to describe that [successful] student in the "four-year answer," and that is a successful student in general chemistry will be a student that is making progress towards a degree for four years and then demonstrates the ability to be productive in a career.*

Successful Students as Engaged Students

A majority of faculty (11) directly used some form of the word "engage" to describe characteristics of successful students. For instance, Jordan (chemistry) said, "*Frequently, my successful students are engaged.*" Sidney (chemistry) claimed, "*One thing is the student has to be willing to engage.*" Peyton (biology) said, "*Successful students are engaged; they show up to class mentally, physically...they're engaged, they're totally engaged.*" Jackson (mathematics) noted, "*Someone who is engaged with learning the material.*" Finally, Drew (mathematics) said, "*I think the two main words I would use are engagement and persistence.*"

We grouped claims around student engagement across Kahu's (2013) behavioral, cognitive, and affective domains. Although we find it useful for our later discussion, we also note that this categorization should not convey strict boundaries as faculty. Faculty frequently suggested that successful students were engaged in more than one of these areas.

Student Behavior

Behavior in the Classroom.

A majority of faculty (14) described multiple kinds of behavior as suggestive of engaged students and, thus, successful students. These behaviors included time spent on, the effort put forth on, and participation in course activities, and interactions with others. For some, this indicated students' persistence, often in light of some challenge to learn the material. In this excerpt, Kelly (mathematics) described students who persevered through difficulties and possessed the self-confidence and determination to complete the task, even though it might be difficult and take extra time.

> *The qualities that I consider for a successful student is, I think the top one is persistence. The fact that they won't give up when things get difficult is key, and the other is self confidence that they can do whatever task they're given and it might take work, and you might have to struggle for a while, you might have to step away for a day and come back and take a fresh look at the problem.*

Some faculty described more specific observable student behavior, like attending class, doing homework, and coming to their office hours. Madison (mathematics) said, "*I think the first and foremost thing is attendance and doing the homework.*" Tracy (chemistry) offered, "*Students who come to class and participate.*" For instance, Jackson (mathematics) said:

Someone who seeks help when they need it and goes to either my office hours, or we have a math learning center, or visits the teaching assistant's office hours and takes advantage of the resources, would be another characteristic [of a successful student].

Behavior Outside Course-Related Tasks.

Several faculty (6) also spoke of successful students exhibiting behaviors outside of students' regular course-related tasks. Faculty viewed students as successful if they could "handle" school and be engaged in outside activities simultaneously. Lynn (engineering) said that student resumés showing extracurricular activities signaled, to them, students who can "handle" both school and other activities, connoting their greater potential for success, generally. Lynn said:

I always say if you have two identical resumés and one has club activity and outreach, and the other one doesn't, you're always going to go for the one with the club activity and outreach because it just shows that they can handle these things together as they've gone through the four years or however many years of college.

These faculty perceived this balance enhanced students' overall well-being and reduced stress and, ultimately, promoted more academic success. Jordan (chemistry) felt successful students had a history of participating in other campus activities. They stated:

Successful students are frequently engaged across the campus as well, so it's not just in my course, I find kind of a history of them being engaged in clubs and sports or something of that effect.

Alex (chemistry) described how successful students make social connections, which may increase their university-based success and success later in life. They said:

[speaking as a student] "I'm going to balance my lifestyle for academics and social and I'm going to meet people and it's going to be an experience." And in some amount of time, which many of course hope that it's four years, sometimes it's five or six, that they will leave here with such an increase in their value that they will go and pursue a career which will ultimately get them the rewards of life.

In contrast, two faculty perceived successful students were "the lucky ones" not to be burdened by outside stressors like jobs or family responsibilities, as related behaviors could restrict a student's ability to engage with educational activities and work. One of the faculty, Peyton (biology), said:

> *I would also say the longer I teach the more I realize my successful students are the ones that are unencumbered by other life stresses for the most part. So they're the lucky ones, the ones who don't work a ton or who have stable home lives who don't worry about things like that.*

Student Cognition

A majority of faculty (13) perceived students' cognitive engagement as indicative of successful students. Cognitive engagement denotes students' actively trying to learn, acquire knowledge, problem-solve, and reflect on their learning. We have separated cognitive engagement into separate categories for emphasis, but faculty perceived these characteristics as interconnected. For example, Alex, a chemistry faculty member, described the pleasure successful students feel when they learn something new and connect that learning to science. This faculty also perceives the affective, emotional engagement connected to the cognitive engagement. They stated:

> *... an effective student is to joyfully learn and make connections, … it's about them [students] learning how to do science and what science looks like ... actually trying to understand the concepts rather than just memorize certain problems.*

Learning and Acquiring Knowledge.

Several faculty (6) described successful students as those actively trying to learn and acquire knowledge. For example, Jodi (biology) talked about an introductory biology course in which successful students do more than just memorize or learn the vocabulary. A successful student begins to learn how to "do biology" and how to be successful at learning science. They said it in this way:

> *So it's an introductory course, and there is an element of memorization and learning vocabulary that has to go into an introductory course, but really what I'm trying to get my*

> *students to see and understand is how you do biology, what types of biology are out there, and how you can be successful at learning in a field that is like biology.*

Jackson (mathematics) said, "*Someone who is engaged with learning the material and I think the best word might be present and actually trying to understand the concepts rather than just memorize certain problems.*" Jamie (physics) said successful students look over their learning assessments and work to learn what they do not seem to be understanding. They said, "*A successful student in my courses evaluates exams and looks over them to find out what they got wrong, figures out how to get to the right answer prior to the end of the term.*" Casey (chemistry) said that successful students "*apply what they've learned in a novel situation.*"

Problem-Solving.

A few faculty (5) described successful students as those who could effectively solve problems. One faculty described how successful students in his courses could move beyond memorizing the content, applying it to different scenarios. Robin (physics) said:

> *Every class pretty much until this point is we go through a whole bunch of content, we say you need to learn this content, maybe you have to do some synthesis where you're connecting content, but it can largely be done at a rote memorization level with open notes. So you've got all the equations, you've got all the theories in front of you, but you're never going to see a particular problem that you practiced on the exam, because I'm actually asking you to take and apply this abstract set of principles and ideas and mathematical reasoning and physical reasoning, conceptual reasoning, all to a different problem.*

In this excerpt, Leslie (mathematics) described successful mathematics students as utilizing problem-solving skills to help them solve challenging problems. They stated it this way:

> *Successful students are capable of doing mathematics, just because they don't see a solution path right away or the answer right away, that doesn't mean they're not capable of doing mathematics...So building some really good thinking and reasoning skills that can help them solve problems in multiple contexts.*

Reflective around Learning.

A few faculty (3) described successful students as those who reflected on what they were learning and their actual learning processes, sometimes interacting with others. In one example, Jamie (physics) said that successful physics students talk with each other about their understanding of the concepts. They said, "*I think understanding the physics also requires that they discuss with each other their interpretation of what's going on there.*" Jodi (biology) described successful students as those that reflect on how they learn. They said, "*There's more of this sort of competency, and then there's also this meta cognitive piece about how do I [student] learn biology and why is it important to me."*

Another faculty spoke of successful students as those who were able to critically review themselves to practice the skill of self-reflection and learn how to see their own mistakes and be able to avoid them. They have students talk to one another as another way to reflect on their learning. However, they also describe a lack of reflective learning as a characteristic of unsuccessful students they perceived as unable to engage in learning effectively. They describe unsuccessful students as those barely educated above a middle school level, and, as such, they were unable to engage in reflective learning. They also perceived college entry standards as inadequate in keeping underprepared students out of their classroom. Jordan (chemistry) talked about what they did:

> *What I do is encourage the students to critically review me. And when they critically review me, I use that as a doorway to get them to think about whether or not they have made similar mistakes and how they can avoid those mistakes and I get them to talk about that or engage in some sort of an evaluation of their mathematics...My average student is just barely literate enough to participate in a critical review of something written above an eighth grade level, and I don't see it getting a whole lot better in the near future because the entry standards for the school are a challenge.*

Student Affect

A few faculty (5) described successful students as those demonstrating student affect or certain emotional states around new material and experiences, indicative of their engagement, and thus, success.

Enthusiasm and Interest.

A few faculty described successful students as enthusiastic and interested in the subject and material. Logan (engineering) described successful students as being excited about course material and its possible application:

> *I feel like I've had a lot of them, and they're folks that really are pumped up about the material, like they had no idea this was so cool and how it relates to everything.*

Jodi (biology) detailed a successful student as someone who is enthusiastic about learning the material, which can translate to a deeper understanding of related careers:

> *…feeling like, wow, I figured out how to learn biology, and I learned a ton, and I could walk out of here and feel like I know what a biologist is doing.*

Motivation.

Two faculty portrayed successful students as those who were self-motivated. In this excerpt, Tracy (chemistry) described successful students feeling agency and efficacy in course activities, generally doing the work needed to understand course content. Tracy described students in this way:

> *… being self motivated or self sufficient in being able to read material presented in the text or in publications and come to us with questions if they had them or do the exercises to be sure they were getting the material and understanding it.*

Lee (engineering) described successful students as those intrinsically motivated to the degree that a faculty member's role can be more of a facilitator of student learning, allowing students to take more ownership of it.

> *[students] get to a point where they're intrinsically motivated to learn and you are really kind of facilitating their learning…[students think] hey, I'd really like to learn more about this thing. For me a successful student is someone who's taken ownership of their learning and they're not in the mode of, it's your job to give me everything that I need to learn this material.*

Instructional Strategies Faculty Used to Help Students be Successful in Their Courses

Faculty spoke of a wide range of instructional strategies they described as effective in developing and cultivating student success—faculty detailed lecturing strategies as well as specific evidence-based instructional practices (EBIPs). Faculty often spoke of instructional strategies as fostering student engagement in some way. A few faculty discussed instructional strategies promoting student success in light of their perceptions of differing levels of students' potential for engagement.

The Use of Lecture-based Instructional Strategies

More than half of the faculty (10) interviewed mentioned using lecturing as an instructional strategy within their courses when asked about fostering student success even if they recognized some limitations. The term lecturing refers to teaching where faculty deliver instruction or content primarily through talking, frequently while positioned in front of the classroom.

Some faculty spoke of trying to minimize their presence in the classroom to cultivate more student success, even if they felt some lecturing by them to be necessary. Leslie, a mathematics instructor described how they decentralized themselves as the mathematics expert or authority but they still talked about also needing to cover the content that students needed.

They said, "*I really try to decentralize myself as the mathematical authority in the room…[but] I feel like I have to make sure I get through all the content.*"

Tracy (chemistry) also described how they were trying to minimize their lecturing time overall to cultivate student success. Although they felt lecturing was an integral part of their teaching practices, they admitted that it did not always foster students' success or engagement.

> *I really move to try to avoid standing up there and lecturing for extended times, which I don't think supports all of those things [characteristics of successful students] or even many of them. But inevitably there is some lecture.*

None of the faculty who discussed lecturing claimed it as their only means of conveying content to students. To improve student success, faculty used other types of lecture-based instructional strategies to engage students through questioning strategies or providing periodic opportunities for students to work on problems.

In this excerpt, Jackson (mathematics) detailed how they tried to engage students directly in the conversation during lecturing to foster student success. They tried to get students involved by asking questions and waiting for someone to respond to create a discussion. They described how just delivering information was not as effective as engaging students. They stated it this way:

> *I try to make my lectures interactive so that the students are involved, and often I'll ask questions and wait for someone to answer the question and try to create more discussion around the ideas, rather than just me conveying information without engaging the students directly.*

Similarly, Jamie (physics) claimed they lectured and talked too much during class times when asked how they cultivated student success. They described how they attempted to minimize it via several opportunities for students to engage with content through other means. They said:

In lecture, I'm still talking too much, but there's about five or six opportunities where the students work for three minutes or so on getting solutions to a problem.

The Use of Evidence-Based Instructional Practices (EBIPs)

Eight faculty specifically described different kinds of EBIPs in their course design and activities they planned to cultivate student success. They explained how these practices would develop and foster successful students by helping them to stay focused on and learn the content more effectively. These practices included specific course designs and actual student activities.

Course Design and Student Activities

Several faculty talked about designing their courses to foster student success by using specific EBIPs that support and cultivate students' success in their courses. One faculty described how they designed their class so that students would know precisely what they needed to do and would be less likely to fall behind. They describe their instructional approach as highly structured around the content and learning outcomes, with student activities and assessments directly aligned with them. They contrasted their course design as very different from a traditional class that involved lectures and taking exams. Jodi (biology) described it in this way:

I design my classes in what I call a highly structured class and so we try to structure it in such a way that they can't get behind. So by highly structured I mean they are given content every week. It's not like here, come to lecture and then take this exam and then you're done. Then we also use a really heavy backwards design in all the things we do with that where we have learning outcomes that we want them to be able to do and everything we do is aligned to those learning outcomes, and then we tell them all of that.

Another faculty described using a flipped classroom design in which students engaged with the learning materials around a topic outside of class before experiencing instruction on the topic in class. They discussed how students needed practice in applying what they have learned to new situations, and it was essential to have students practice in class so they could see it as an important goal. Casey (chemistry) described their instructional strategies in this way:

> *So like the flipped classroom, they're always working on problems while they're in class. There is virtually no standard lecture that goes on.*

One faculty talked about using case studies to provide students with realistic situations in their engineering courses. Lee (engineering) described how they scaffolded their instruction to provide supportive activities that moved students toward a more robust understanding that did not overwhelm them. Lee said:

> *So for me I think strategies I've used are case studies, kind of guided design in one of my classes where I have tried to make a realistic scenario, but have it scaffolded enough that it doesn't seem totally overwhelming to students.*

Group Work

Several faculty (5) described group work as an effective strategy for helping students be successful. One faculty (Jamie, physics) described implementing class sessions where students worked in groups of three on specific tasks and then presented their work.

> *So they work in groups of three, round tables, groups of three, they have certain tasks, they sit down and work together for fifty minutes, and one of the groups presents their findings, they discuss it, and we go onto the next thing.*

Another faculty talked about using groups as a strategy for cultivating student success that builds interdependence among the students to hold each other accountable for attending class and supporting one another in their group and the course. Peyton (biology) described it as, "*Trying to develop good group contracts with them, so they feel like they have to be there for each other.*"

One mathematics faculty, Jackson, described a strategy they used to foster student success. They put students in groups to take quizzes they determined were particularly difficult. Specifically, they wanted students to work together to solve problems. Through this strategy, they talked about how students were engaging with the content and with each other. Jackson described this strategy in this way:

> *So every couple of weeks without announcement, there will be a quiz, and the quiz will focus on sort of generally more difficult concepts than you would have on a normal exam, but they get to work together, so usually, they're able to figure it out as a class. We give them about fifteen or twenty minutes per quiz to come up with the answers, and that to me fosters engagement, engaging with the material and with each other, and trying to help each other understand the concepts.*

Instructional Strategies that Encouraged Student Cognitive Engagement

A majority of faculty (12) described instructional strategies that cultivated student success and that were closely tied to fostering students' cognitive engagement, which included activating prior knowledge, connecting prior knowledge to new knowledge, applying their learning to new problems, and engaging students in discipline-related methodologies.

The faculty discussed instructional strategies that would help students activate prior knowledge to foster successful students. Peyton (biology) said this would encourage students to recognize what they do not know, the limits of their knowledge, and what they might want to learn. They said:

> *I'm trying to engage what they know already. When we start a topic, start a class period, what do we already know and where are the limits of your knowledge, and what are the things that I think you might be wondering in that sense.*

Similarly, Madison, a mathematics instructor, fostered student success by connecting new ideas to ones that students already understood. They did this to make sure that students were ready to learn and so students could make obvious connections when topics were discussed. They stated:

> *So this idea of connecting something [new learning] to the older stuff that they [students] should know serves as kind of two things. One is just to make sure everybody is up to speed on it so they can make the connections and then pointing those connections out.*

One faculty discussed encouraging student success by designing their instructional activities so that students could apply what they learned to new situations. Casey (chemistry) spoke about how some students resisted doing these kinds of activities, but they felt it was essential to have students do application problems, particularly in a class setting, and to see this as a fundamental goal of learning the discipline. They stated:

> *You have to give them [students] practice at applying what they've learned in novel situations, which is not something they like to do, but that's beside the point. You have to have those types of questions. You have to do it in class. It has to be something that they see as a goal for them.*

Jodi (biology) described an assignment they designed to foster student success. They considered it "authentic scientific practice" to help students engage in scientific thinking and processes such as asking questions, making a hypothesis, collecting data, and writing results that culminate in a scientific-style paper. Jodi also asked them to self-assess and peer assess to practice what scientists actually do. They described it in this way:

> *We wrap all that [class activities] into what I consider to be the authentic scientific practice, where at some point they get to ask a question and make a hypothesis and collect some data and write a results and a discussion and end up with kind of a scientific style paper, but then I ask them to self-assess and peer assess and do sort of the processes that we as scientists do.*

Instructional Strategies that Encouraged Students' Behavioral Engagement

Faculty detailed instructional strategies that would encourage student behavior to lead to more success. For example, faculty talked about using backward design, flipped classrooms, and group work in labs and studios to encourage successful behaviors (see above section for relevant quotes). Along with these strategies, several faculty (9) also described how they designed their instructional strategies to foster student success by encouraging them to talk with each other and their instructors. Robin (physics) described how all of their assignments were designed to be difficult enough to force students to talk with other students or seek help from their instructors to cultivate student success. They said:

> *So I would say the one thing that is sort of a common thread through all of the instructional design that I've done is how do I get people talking. How do I get them talking about physics because if you're talking, you're learning, and so every single thing from lab to recitation to homework, even the challenge homework is designed to be hard enough that most of them will have to seek out help from other students, will have to go online to the support group, will have to go to the "worm hole" which is where the T.A.'s hold office hours.*

Leslie (mathematics) described how they tried not to answer students' questions directly and, instead, encouraged them to talk with their peers as a way to develop successful behavior in students. They described how they had students talk to someone sitting next to them about the problem. They said:

> *So not answering their [students] questions directly. Getting them to talk to peers, if I pose a question to a class and it's just silence in the room, I'll have them talk to somebody next to them for a couple of minutes to talk about the problem.*

Jackson (mathematics) talked about how there might be awkward silences when they asked students questions, and students did not respond. They described how engaging with the instructor, even when students were reluctant, was important for their success. They said, "*I try to get them [students] to respond to me and engage with me, even if that takes some awkward silence periods where I'm waiting for someone to respond."*

Instructional Strategies that Encouraged Student Affective Engagement

A few faculty (5) discussed instructional strategies that encouraged students' affective engagement and thus cultivated student success. They described efforts designed to build students' self-esteem, connect with students through empathy and humor, and encourage students' interest in the content by showing it more relevant in contexts meaningful to students. Kelly (mathematics) tried to influence student success by telling students they could be successful. They talked about being their students' advocates and telling them they were amazing and capable of success. They described trying to build up their self-esteem. They said:

> *I'm a very big advocate of constantly telling my students that they're awesome and amazing and telling them that they can do this and really building up their self-esteem and building up that yes, I agree this feels hard, but you can do this.*

Logan (engineering) used storytelling and humor to connect with students and felt this fostered their success. They described having a great deal of empathy for their students, and they tried to convey that feeling to students through stories and laughter. They said:

> *I tell lots of stories constantly, tell stories. I make folks laugh, and the stories are all related to what's going on … I connect with them [students], make them laugh, I really have a great capacity I feel like for empathy. I have a great capacity to kind of appreciate where they're at.*

Peyton (biology) described how they tried to find something that students would be interested in, and that was unique and relevant to the students to foster success. They discussed how they tried to find something that would be of interest or a unique and relevant topic to students, so they saw a purpose. They described it in this way:

> *I'll try to find something that might peak their interest, something that's unique to humans or that's clinically relevant in some way, or something like that, so it could feel purposeful that they know that information.*

Instructional Strategies in Response to Differing Levels of Student Competency

A few faculty (3) described different types of instructional strategies they thought would cultivate student success that was tied to the different levels of student competency. A few faculty perceived student engagement levels to be different in their lower division versus upper-division classes, which inspired them to use different instructional strategies that they described to help secure each group's success. Drew (mathematics) spoke of using more interactive strategies in their upper-division courses to ensure student success but trimmed them in their lower-division courses. They described limited lecture-based instruction in their upper-division classes, and students engaged collaboratively in problem-solving activities. In contrast, Drew described "quite a bit" of lecturing in their lower-division courses. They described it in this way:

> *I have taught some [upper division] classes where I've done almost completely without lecture and just given students a series of problems to work on collaboratively, and I shy away from being the dispenser of the authoritative answer. When I'm teaching lower-division courses, there's still a fair amount of me talking...or quite a bit of lecture goes on in the lecture part of the course.*

Jordan (chemistry) described students in their lower-division courses to have limited literacy and numeracy skills, which was not conducive to success. In contrast, students in upper-division courses have skills advanced enough to engage in more analysis and conversation around the material, leading to more success. They described their average student as lacking literacy and numeracy skills. The ability to critically review the work was considered an important skill to develop as a successful student. They described it in this way:

> *In [name of lower division course], my average student is just barely literate enough to participate in a critical review of something written above an eighth-grade level. And that's scary to me. Numeracy is comparable. So, in [name of upper division course], they're college numerate, they're college literate. You can have a conversation with them about these things, and they can critically review the work, and they understand what's going on to a degree where they can critically review themselves substantially better.*

Discussion

In this paper, we reported an exploratory study of STEM faculty notions of successful students and the instructional practices they employ to cultivate student success. We found faculty perceive a range of characteristics and factors indicative and predictive of student success. Faculty considered successful students to be those who were "making progress," even if they were not earning high marks in their courses. Faculty described progress as learning course content and gaining new knowledge and skills. Beyond this, faculty broadly described successful students as "engaged" students, which we could group across three domains: behavioral, cognitive, and affective (Kahu, 2013). A majority of faculty perceived multiple behaviors (those directly observable by faculty and those not) as essential characteristics of successful students. Behaviors included time spent and the effort put forth on coursework, participation in course activities (those in the classroom and those across campus), and interactions with other students and instructors. Similarly, a majority of faculty described students' cognitive engagement as indicative of their success. Students' cognitive engagement included acquiring new knowledge, problem-solving, and reflective learning. To a lesser extent, faculty perceived students' affective engagement equated with their success, including students' enthusiasm for and interest in the discipline and their motivation to learn.

Faculty described a wide range of instructional strategies they perceived as effective in developing and cultivating student success. Faculty described lecturing strategies as well as practices known among researchers as evidence-based instructional practices (EBIPs). Although more than half of the faculty described lecturing in their courses, they also detailed minimizing the length of time they spent lecturing, using more questioning techniques, and group work to make their classes more interactive and supportive of student success in allowing students to be more engaged. Faculty detailed numerous types and uses of EBIPs to cultivate student success, including around course design and other instructional strategies. Faculty described using backward design, flipped classrooms, case studies, and group work as strategies to cultivate student success. Faculty also detailed how they differed their instructional strategies based on their perceptions of the potential level of student engagement across students in their courses, describing using less obviously engaging techniques in lower-division versus upper-division courses.

A majority of faculty discussed implementing instructional strategies they thought would engage students' cognition, prime them for, or solidify learning something new, such as activating prior knowledge, connecting it to the new knowledge, applying knowledge to new situations, and engaging students in discipline-related practices. A majority of faculty also discussed implementing instructional strategies they thought would cultivate students' behavioral engagement, like fostering students' interactions with other students and faculty. Finally, some faculty detailed instructional strategies they thought could impact students' affect to increase their self-esteem and interest in the subject and material. To accomplish this, the faculty used empathy, humor, and statements affirming students' abilities.

In general, faculty saw student engagement as essential to learning and success. While the importance of student engagement to their success is surely evident to many readers of this paper, we contend that this is still a meaningful finding. Researchers have recently documented that STEM faculty largely engage in lecturing, favor and justify it over the use of EBIPs, and are sometimes unaware that EBIPs can improve their courses, often via student engagement (Bathgate et al., 2019; Freeman et al., 2014). Our findings contradict the perception that STEM faculty are homogeneous in their practices and commitments, largely unaware of EBIPs, or resistant to use them in their courses (e.g., Bathgate et al., 2019; Patrick et al., 2016). We found otherwise and confirmed that STEM faculty, even at a research university, break some assumptions around their teaching-related weaknesses and strengths (Bouwma-Gearhart, 2012). The fact that the STEM faculty in this study also knew about and tried to implement EBIPs that research confirms helps facilitate student engagement is encouraging, including those hoping to improve experiences among underrepresented student groups in STEM (Haak et al., 2011).

Indeed, many faculty seemed to recognize the limitation and impact of solely lecture-based instruction on students and attempted to include EBIPs (e.g., interactive questions, small group work, discussions) throughout their instruction. Their claims of implementing EBIPs matched Hora's (2015) detailed observations of STEM faculty teaching practices and his caution that wide-held assumptions and conceptions around faculty lecturing are narrow and inaccurate and discounting of faculty practice that incorporates student-engaging practices within and alongside lecturing. To a biased or untrained observer, a faculty member may appear to be “only lecturing” even as they engage students with meaningful questioning strategies or have students work through a problem at their seats during a brief pause in their talking. These strategies surely enhance student success. This said, we do not know the realizations of our faculty participants’ claims as actual faculty practice, and we heed some caution against assuming faculty claims about their teaching practices are consistently accurate (Ebert-May et al., 2011). Still, much of what we heard from faculty indicated a commitment to engaging students in multiple ways and understanding practices to elicit this, all of which indicate faculty schemas and dispositions to build upon by those who want to help faculty realize improvements in their teaching. We echo others in asserting that uncovering these realities are instrumental in designing and implementing initiatives meant to help faculty change practice, to meet faculty where they are at, and to consider faculty partners in improving postsecondary STEM education in their courses and those of their colleagues (Bouwma-Gearhart & Ivanovitch et al., 2018; Bouwma-Gearhart & Lenz et al., 2018).

We note some possibilities for attention for these initiatives from our research as well. Our recommendations build on those of other researchers that have demonstrated that educational interfaces are comprised of norms and expectations that are often implicit (Orón Semper & Blasco, 2018). Educators' implicit expectations, specifically embedded in various activities and structures, such as syllabi and other course materials and discussions with students, stand in contrast with their more obvious indications (Orón Semper & Blasco, 2018). Simply put, faculty may not express their implicit expectations and related assumptions. In our study, some faculty indicated students to be successful even when not earning an A grade, potentially not evident to students whose experiences in other educational settings might have convinced them of otherwise. This may lead some students not to know that they are achieving meaningful success (e.g., the student earning a C, or even B, in a course), which may, in turn, discourage their future success in that course or, even, in the program or discipline.

Equally, if not more, concerning is that ambiguity of faculty expectations may also impact students' positioning themselves to be successful. Some faculty expectations and perceptions around student behaviors, such as students taking advantage of office hours, raising hands, and asking questions during class, that remain implicit may beget unexpected (and unintentional, on the part of faculty) negative consequences for students (e.g., Shapiro & Sax, 2011; Orón Semper & Blasco, 2018). Faculty also interpreted students' affective engagement (i.e., interest and enthusiasm) around a subject as indicative of their success. Actions that are often nonverbal in nature (e.g., facial expressions or verbal responses) can depend on the students' comfort levels and personal preferences with expressing those emotions. Several faculty spoke about how they would talk to students and engage in conversations that provided them with feedback about their progress or understanding. However, many of these interactions were informal and may not have involved most students, those succeeding as well as those struggling. Faculty practices and expectations may ultimately assume and encourage a particular type(s) of student, from groups traditionally successful in STEM. Not understanding the implicit or hidden expectations of faculty, women, racial/ethnic, and other underrepresented groups may not recognize, be positioned to utilize, or confident in their ability to use the resources available to them (Kahu & Nelson, 2018; Shapiro & Sax, 2011).

We call out the faculty expectations and perceptions noted above as based on, and reinforcing, inaccurate assumptions around *meritocracies*, in this case, learners' abilities reflected accurately by their progress and measurements on traditional academic indicators and metrics, such as grades (Guinier, 2015). Faculty frequently used standardized midterms and final exams as the predominant determination of grades and student success. In one case, a faculty member only shared an overview of how well the class performed on the exam in the form of a bell curve and did not share the student's individual exam performances with them. In other cases, faculty assumed that students came to college to socialize and earn a degree that would provide them with a valuable career and good life, which assumes a predominantly young student who is unencumbered by other life responsibilities. Meritocratic assumptions and resulting environments are especially problematic for historically underrepresented groups in education environments; in postsecondary STEM, these groups still primarily are those not white or male (McLaren, 2017). A system based on notions of meritocracy places the burden of achievement on the individual's shoulders. Therefore, succeeding or failing becomes the student's responsibility and assumes the student has the knowledge and understanding of the explicit and implicit expectations, norms, and practices that may be prevalent in many STEM courses. Long held cultural norms (e.g., competitive, merit-based admissions, and advancement criteria) are reinforced and may continue to signal to some students that they are not suited for STEM careers (Johnson, 2007; Rainey et al., 2019).

STEM faculty may have a difficult time seeing these biases. Overall, the educational interface is complex, with those interacting in it (including faculty and students) somewhat blind to all of the influencing structures and practices impacting their perceptions and actions (Varelas et al., 2015). And some of this may also be due to the nature of the disciplines. STEM classrooms and disciplines are often presented as neutral to race, ethnicity, and gender. Thus, responsibility for learning is centered on the student, a decisively narrow focus in discussions of improving postsecondary educational outcomes. Faculty perceptions or assumptions that student learning is the student's responsibility connotes a one-sided effort to support student success, focused on changing students' behaviors and attitudes. This perspective assumes students show up inculcated into STEM environments and fails to recognize the complexity of college classrooms and the institutional realities that exist (e.g., large lecture classrooms, competitive admissions processes, access to technology). Notably, a few faculty expressed an awareness of structures that may act as barriers for some students, such as those who described minimizing exams as the sole determinant of grades or attempting to change departmental policies around group exams.

Implications

Not recognizing the norms and expectations that come together in the postsecondary STEM education interface promotes a meritocratic model and may disadvantage students from diverse social, cultural, and economic backgrounds. Beyond perceptions already discussed above, several faculty members we spoke with also likely considered the notion of successful students in relation to the traditional, narrow view of a college student as a young adult (18-22) who goes to college for four years right out of high school, earns a degree and obtains a job associated with that degree right after graduation. For many faculty, successful students generally did not have to support themselves financially and, thus, potentially have powerful social networks or family structures. Such affordances of student success, like some noted above, are arguably outside of faculty control, further shifting responsibility for student success away from faculty, programs, and institutions.

We acknowledge the broad array of faculty perspectives regarding the characteristics of successful students and teaching strategies. We also acknowledge that perspectives that represent actual barriers and challenges to student success were difficult to detect in the data. And research surely suggests that students experience and interpret college environments differently (Whittaker & Montgomery, 2014) and may bring a range of expectations and commitments to their classes (Messineo et al., 2007). Students from underrepresented groups will not all struggle with the faculty's implicit and tacit expectations. Yet, we assert that faculty expectations that may otherwise appear neutral can influence many students' conceptions of their success and willingness to engage in ways that lead to their success.

We have greater concern for most students regarding the faculty expectations we heard of for this study and how these may be reflected in their curriculum and instructional strategies, and other teaching artifacts. For instance, faculty spoke about structuring their courses differently depending on students' perceived abilities and preparedness and in faculty's felt need to cover the content. Faculty who perceived students as lacking in academic preparedness, often those in lower-division introductory courses, were more likely to cover content through lecture-based approaches, even though they were aware of the limitation of lecturing as the most effective teaching strategy. Faculty expressed frustration with students' limited literacy and numeracy skills and lack of students' abilities to review their work critically and discussed how lower-division course students might be less engaged. We see the potential for a self-fulfilling loop here, where faculty perceive students to be less engaged, so engage them less, further guaranteeing less student engagement (and success). Some faculty may still need to consider the need to better engage all learners and strategies to do so even when they perceive that students may lack some knowledge or skills.

We believe our findings hold other implications for faculty and those working to support them. Studies of faculty adoptions of EBIPs suggest that faculty may be reluctant to try EBIPs because of a lack of experience, time, or incentives (Brownell & Tanner, 2012; Graham et al., 2013). However, research also suggests that carefully structured professional development activities that allow instructors to incorporate EBIPs show improvements in student engagement and achievement and increases in faculty use of EBIPs (Addy, 2011; Mataka et al., 2019). Faculty in our study discussed and claimed to implement various teaching practices that researchers have linked to student success, including infusing EBIPs into their lecturing. Faculty were not tied to just one teaching strategy and indicated they tried to adapt their instructional practices to meet their perceptions of what students needed, even as they faced concerns of other barriers (e.g., time constraints and content coverage). The use of various EBIPs by faculty suggests an awareness of the potential for engaging students in various ways and understanding various practices that can help students achieve success. As we have argued limitedly elsewhere, STEM faculty's understandings and practice attempts should be acknowledged, applauded, and built upon.

While faculty primarily discussed the characteristics of successful students in the context of their courses and disciplines, they also equated success with a more holistic view of students persisting beyond their classes, completing a degree, and pursuing a STEM career. These faculty perspectives suggest broader opportunities for departments to build more obvious networks and support strategies with student service personnel that broaden faculty knowledge of student supports outside the classroom. Tapping into faculty members' espoused commitment to helping their students succeed can open the door for these same faculty to explore more EBIPs, that continue to foster the kinds of characteristics that faculty actually value most in their students and are seen as critical markers of success.

Of course, faculty members operate within contexts that allow for considerable autonomy over their teaching. They also influence other faculty within their disciplines, and those that they trust and respect may be best positioned to help them notice and challenge their assumptions and perceptions, and practices that may remain tacit to students. Peers might help other faculty better acknowledge and understand that the educational interface (Kahu & Nelson, 2018) can be full of many tacit rules and norms, thus allowing those most embedded in the system (i.e., themselves) not to recognize that those newer to a system or less knowledgeable or influential within it (i.e., students and especially minorities) can be somewhat unaware of how things are done (Varelas et al., 2015). Those supporting improvements to faculty teaching can promote and support continual monitoring by faculty of the affordances and constraints that their expectations, perceptions, and related instructional structures might create around student success. Faculty engaged in improvement initiatives would benefit from reflective activities that have them investigate their perceptions of successful students and the instructional practices designed to foster student engagement, their successes, and less positive potential unintended consequences.

Conclusions and Future Directions

Using interviews from 19 STEM faculty, we sought to examine how faculty described their students, particularly those viewed as successful, and how they thought about their instructional practices that supported those students. We found faculty perceptions of successful students varied widely and found a pattern of faculty members' conflation of "successful students" with the concept of student engagement, specifically students' behavioral, cognitive, and affective actions or characteristics. The STEM faculty who were involved in this study were committed to supporting students, and they recognized that student engagement, in its various forms, was key to achieving success. The wide range of instructional strategies, many of them research-confirmed in fostering student success, indicated the faculty's motivation to support students engaging in the content. It was clear they wanted their students to learn and were concerned when students were unsuccessful. Still, we found that some faculty still claimed to continue to rely primarily on lecturing as a strategy, without obvious incorporation of EBIPS, especially in lower-division introductory courses, where research suggests the use of EBIPs is actually most effective and needed (Haak et al., 2011).

However, our dominant concern is that faculty may assume that students know how to engage effectively to be successful in STEM classes and courses. We are also concerned for faculty making assumptions about indications of student engagement, especially around behaviors that some students may not know, or feel empowered, to do. Like other humans, faculty may be unaware of their perceptions and their consequences, leading to further reification of implicit expectations and the assumptions associated with them (Pajares, 1992). Such perceptions may underlie and reinforce educators' unspoken expectations that privilege some student groups over others. We advocate for this finding to become more understood and challenged by faculty, leaders, and professional developers. This consideration may even add to our growing understandings around the underrepresentation of women, students of color, and other groups in STEM disciplines, a notably complex problem with roots in many related phenomena.

We encourage future scholarship around faculty perceptions and practices and their impact on student success and persistence in STEM fields. Research is needed that further examines these phenomena with a more significant number and diversity of faculty, with an exploration of other contextual factors (e.g., type of institution, discipline, teaching, and teaching-related professional development history) and faculty members' social identities (e.g., gender, race, and ethnicity). Additionally, we encourage research that explores faculty members' perceptions in light of their actual teaching practices, including their implementation of EBIPs and their impact on student engagement.

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Appendix A

Faculty Interview Questions

1. I'd like to know more about your position at [Name of University].
    a. Specifically: What is your official title?
    b. What classes did you teach this academic year, 2016-2017?
    c. Have your teaching responsibilities changed since last interviewed for this project?
    d. How much autonomy do you have over what and how you teach?
2. Do you interact regularly with any others concerning issues of teaching and learning?
    a. [If yes], please provide detail regarding those interactions: including
        i. who? 1. Are these people in your discipline/department/program?
        ii. how often?
        iii. regarding what specifically?
    b. What encourages or discourages these interactions?
    c. Has [Name of Initiative] influenced these interactions in any way?
3. I'd like to hear about your engagement with the [Name of Initiative] project. Specifically:
    a. What has been your affiliation with the [Name of Initiative] project? What activities have you attended?
    b. Have you noted any impact of [Name of Initiative] on you?
    c. Have you noted any impact of [Name of Initiative] on others?
4. Please describe any evolution in your teaching practices over the last couple of years that you can attribute to improvement initiatives or professional development activities. [If not mentioned, probe for specifics via questions a and b.]
    a. Have any university or departmental initiatives or teaching professional development opportunities impacted this evolution?
    b. Has [Name of Initiative] influenced your evolution in any way?
5. I'd like to hear about your assessment practices while teaching.
    a. To what extent do you collect data/information about student learning?
    b. Are you teaching practices informed by data/information about student learning?
    c. Are there means in the classes/courses that you teach for students to reflect on their own learning data? [If yes], Can you detail these processes?
6. Describe a successful student in the courses or programs in which you teach.
    a. Overall, what do you consider as the most effective teaching strategies towards developing these things?
    b. To what extent do you employ these teaching strategies?
7. A goal of the [Name of Initiative] project is widespread improvement to teaching practices and learning outcomes in undergraduate STEM education across [Name of University]. Our general strategy is promoting educators' learning about evidence-based instructional practices via interactions with other educators.
    a. What do you think about this goal and strategy? Do you have any evidence that widespread improvement to teaching practices and learning outcomes in undergraduate STEM education have happened in the last couple of years at [name of University]

b. Can you attribute any changes to the [Name of Initiative] project?

c. Have you noted any affordances and barriers towards widespread improvement to teaching practices and learning outcomes in undergraduate STEM education, that can inform efforts like [Name of Initiative]?

8. A specific goal of the [Name of Initiative] project was to promote active learning and cooperative learning, especially in large, introductory, gateway courses. We define active learning and cooperative learning as X [definitions provided to interview on a handout]

a. What do you think about this goal and strategy?

b. Do you have any evidence that promote active learning and cooperative learning has increased in large, introductory, gateway courses in the last couple of years at [name of University?

c. [If so] Can you attribute any changes to the [Name of Initiative] project?

d. Have you noted any affordances and barriers towards active learning and cooperative learning has increased in large, introductory, gateway courses, that can inform efforts like [Name of Initiative].

Appendix B

Codes and Descriptions

Code Names ● Childcodes	Code Descriptions
Characteristics of successful students	Any words/phrases used to describe characteristics of successful students
Student Engagement	Any mention of the word engagement or some form of the word engage when talking about students. This concept may be implied in how the faculty describes students but generally equates to behavior, cognition, and affect
● Behavior	Describes students' outward actions, such as time spent, effort put forth, participation in activities, and interactions with others Examples include raising hand in class, asking questions, going to office hours, doing homework, using resources.
● Cognition	Describes students in terms of learning, acquiring knowledge, problem solving, and reflections on their learning
● Affect	Describes students' emotional state with respect to education- or learning-related activities, such as enthusiasm, interest, or motivation in a particular topic.
Instructional Strategies	Any mentions or description of a teaching strategy
● Lecture	Any mention of lecture-based instruction
● EBIPS	Any mention of evidence-based learning practices including active learning strategies that engage students in activities
● engage behavior (11)	Instructional strategies that encouraged students to engage in behaviors related to

	being successful
• engage cognition (12)	Instructional strategies that encouraged students to engage in terms of learning acquiring knowledge, problem solving, and reflections on their learning
• engage affect (6)	Instructional strategies designed to engage in students' emotional/psychological state with respect to education- or learning-related activities, such as enthusiasm, interest, or motivation in a particular topic.