The Importance of Faculty-Student Connections in STEM Disciplines: A Literature Review

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Abstract

Despite an alarm raised by Seymour and Hewitt (1997) describing science, engineering and mathematics programs as chilly and unwelcoming, students continue to report significant feelings of hostility and a lack of caring when characterizing the professor-student relationship. The negative feelings correlate with poor course performance, lower grade point average, and attrition from the science, technology, engineering and mathematics (STEM) disciplines (Micari & Pazos, 2012; Vogt, 2008). A review of the scholarly research may offer educators compelling evidence to change attitudes that are currently characterized, with an expectation of attrition, as a natural and useful action in an environment that places retention responsibility onto students. In contrast, a shift to a professor-student connection featuring a supportive and caring relationship can promote student success. To decrease attrition and meet employer demands for graduates, STEM disciplines must seek a change in academic culture away from survival of the fittest to a nurturing experience that supports achievement.

Introduction

When Seymour and Hewitt (1997) characterized the climate of the science, technology, engineering and mathematics (STEM) disciplines as chilly and unwelcoming, many faculty members supported the notion, not because it was true and negative, but was true *and appropriate*. Science and engineering professors commonly see their role as educators aligned with the production of high quality graduates, promoting the attrition of weaker students (Kokkelenberg, & Sinha, 2010; Seymour & Hewitt, 1997). Faculty members often consider student withdrawal as a sign of successful instruction, thus eliminating incapable students unfit for the rigors of scientific inquiry.

The infamous speech commonly delivered during the first lecture in calculus-based physics or organic chemistry courses, instructing students to look to their left and look to their right to identify students who would drop the class, promoted a culture of high standards and high stress that is perceived to ultimately yield excellent scientists and engineers. Professors proclaimed that hard work alone was the key to success (Micari & Pazos, 2012). *Students* failed and dropped out of their discipline regardless of the actions of the educators. Institutions had little impact on persistence.

Unfortunately, educators failed to examine and consider the characteristics of the learners who left the chilly climate disciplines. Faculty members were certain that low performing students dropped out, without analytical evidence. Seymour and Hewitt (1997) were the first to study the exiting group of students, but numerous studies in the decades following their publication have arrived at the same conclusion, high performing students leave the STEM disciplines as frequently as the underprepared or low performers (Eris et al., 2010; Marra, Rodgers, Shen, & Bogue, 2012; Wagner, Christe, & Fernandez, 2012).

Faculty members play a significant role in student persistence in their major (Braxton, Milem, & Sullivan, 2000; Pascarella & Terenzini, 2005). This paper seeks to synthesize and disseminate the factors associated with faculty-student interactions outside of the classroom. Simple instructor actions can improve the faculty-student relationship and increase student persistence in STEM disciplines, raising overall degree attainment (Vesilind, 2001; Vogt, 2008). This paper will seek to discuss the myth that attrition is a natural process that eliminates weaker students, supporting the notion that faculty members can take specific actions outside of the classroom to promote the retention of good students.

Theoretical Foundations

Many theoretical models exist to characterize general student persistence and withdrawal from college. Tinto (1993) suggested a sociological approach to the interpretation of the causes of student leaving. His ideas contrasted more prevalent persistence views that aimed the cause of attrition at the student, relating to "personal failure" (1993, p. 85). Tinto encouraged educators to examine the relationship between students and faculty members, suggesting that the connections between social experiences and academics promote commitment to degree completion. Learner academic and social integration forms the foundation of Tinto's persistence theory.

Student involvement, according to Astin (1999) is the "amount of physical and psychological energy that a student devotes to the academic experience" (p. 518). Astin's theory incorporated both active behaviors such as *participate* and *tackle*, as well as internal behaviors such as *value* and *emphasize.* With these ideas, Astin suggested that academic success requires, "sufficient student effort and investment of energy" (p. 522), simply teaching courses to passive students does not result in widespread degree achievement. Essentially, faculty and staff should shift their focus from course content and teaching techniques and instead examine student involvement, including connections with faculty, staff and administration.

Perry (1970) postulated a theory of cognitive development of college students. His characterization of the process of learner growth offered educators a vital perspective, asking educators to determine if they *teach content or teach students.* Perry suggested that student learning occurs when instructors support and encourage students, featuring a strong connection between professor and student.

Problem

Attrition from STEM majors is a profound and complex challenge. Despite a national call to increase the number of science, technology, engineering and mathematics (STEM) graduates, less than half of students who begin in a STEM major graduate (*Higher education,* 2006; National Academy of Sciences, 2005; Perna et al., 2007; Hartman & Hartman, 2006; Veenstra, Dey, & Herrin, 2008). This significant drop out rate is a disservice to students and a challenge for society in general.

As educational institutions explore solutions to the STEM retention challenge, numerous studies have concluded that faculty members play a critical role in student decisions to leave STEM disciplines. Yet faculty members do not recognize, "the critical role they play in a student's decision to persist" (Vogt, 2008, p. 27). Micari and Pazos (2012) explained, "despite all of the literature-based evidence pointing to the importance of student-faculty interactions in college, many faculty overlook, or underestimate, the impact they have on their students" (p. 45).

Educational innovation and advancement in ideas and teaching methods are readily available in STEM disciplines, yet lack profound impact on students (Jamieson & Lohmann, 2012). Instead, instruction is still based on faculty experiences as teachers and students (Mastascusa, Snyder, & Hoyt, 2011). The lack of a reward system for innovation drives pedagogical change into the "valley of death" (p. 1), without widespread adoption or application. Worse, improvement efforts have been limited to better teaching in the classroom without an exploration into the "social side" of the student experience (Rodgers & Marra, 2012, p. 43).

STEM educators have degrees earned abroad, especially from cultures that exhibit a *large power distance* social dimension, where classroom interactions are predicted on unwavering instructor honor and respect (Hofstede, 2010). Should faculty members mirror their personal cultural experiences in the classrooms of the United States, demonstrating distance from students, learners may interpret the instructor attitudes as aloof and uncaring.

The problem is multi-faceted. Faculty members do not connect with STEM students adequately and do not understand the benefits of doing so. Mastascusa, Snyder and Hoyt (2011) postulated that the problem for STEM educators is, "that we don't think there is a problem" (p. 1). In addition, faculty perceptions of interpersonal experiences with students do not match students' perceptions (Vogt, 2008). Without an understanding of the importance of the role of faculty members in learner retention, educators may unknowingly play a negative role in student success and STEM degree achievement.

Lessons from the Literature

Research findings can support the design of best practices to promote faculty-student connections in STEM disciplines. Most science-focused professors can evaluate and respond to evidence-based recommendations. With this in mind, the literature forms an excellent foundation for the development of practical guidelines. However, the paucity of publications exploring the student-professor relationship hinders the availability of compelling evidence for change. Hong and Shull (2010) asked, "if faculty play such a pivotal role in supporting and retaining STEM students. . . why are there so few studies that seriously explore this variable?" (p. 267).

Student Perceptions of Faculty Members

Several quantitative studies offer information linking student performance and perceptions of positive faculty connections. The association between student-reported positive feelings and learner academic confidence, self-efficacy, grade point average and retention can guide educators to understand these connections. The studies of Micari and Pazos (2012) and Vogt (2008) offer quantitative evidence that, "faculty have the ability to affect student performance, and thus his or her persistence" (Vogt, 2008, p. 34).

Micari and Pazos (2012) documented a correlation between a student's grade in organic chemistry with the feelings of the learner regarding the connection to his or her professor. Three qualities comprised a positive relationship: approachability, respect for students and the faculty as role model. Micari and Pazos (2012) also found that a strong student-perceived relationship with the instructor increased the students' confidence in course success.

Vogt (2008) also documented the connection between academic success (as defined by grade point average) and positive feelings toward faculty members. The researcher documented the changes in student's self-perceptions as a result of "faculty distance," lowering academic confidence and self-efficacy (p. 27). To improve the student-professor relationship, Vogt (2008) documented the importance of faculty members, "to make themselves available to students" (p. 34).

Hong and Shull (2010) conducted a qualitative study to explore the role of faculty in retaining STEM students. When interviewing students, the researchers identified a common theme: the absence of "any positive relationships" with faculty members (p. 274). Learners described their professors as, "insensitive to their learning and personal needs" (p. 274). Students described feeling humiliated and insulted, promoting an antagonistic long-term relationship. In contrast, learners also identified a few professors who displayed caring qualities, such as engaging in conversations outside of class, providing support during challenging situations, or expressing concern about their professional future.

Suresh (2006) studied persistence for engineering students and found that perceptions about faculty behaviors correlated with grades in challenging courses. Learners reported that they, "felt that the professors were intentionally making courses difficult in order to weed out students" (p. 230). Students described feeling like being in a "mental battle" with the academic program and those who persisted described refusing to be "broken down by it" saying, "I often felt that it was the survival of the fittest" (p. 231).

Institutional Interventions

Seeking to purposefully connect faculty and students, institutions may offer programs to initiate contact that could prove beneficial to student retention and success. Faculty mentoring programs may focus on general support or discipline-specific connections through the research laboratory. Professors who mentor undergraduate students often link professional practice and hands-on experience through research opportunities.

Mentoring. Academic programs have established mentoring programs to promote close connections between faculty members and students. STEM disciplines may lack strong support or widespread usage of this approach to student engagement (Griffin, Perez, Holmes, & Mayo, 2010). Mentoring can promote personal motivation, develop feelings of encouragement toward academic success, and encourage discipline-specific connections. The Arizona State University report (2007) prepared to address STEM persistence concerns and recommended each freshman student be connected with a faculty mentor to promote a "sense of belonging" (p. VI-73). Upper division students as peer mentors may serve as a supplement to faculty connections and can offer freshman students, "someone there to help them at the instant they need it" (Budny, Cheryl, & Beth, 2010, p. 22).

Vesilind (2001) described mentoring engineering students as an "offer of friendship as a part of the professorial role" (p. 408). He encouraged institutions to train faculty members to be excellent mentors and reward and recognize their efforts. Student feedback should guide the relationship and enhance future experiences. In addition, Vesilind (2001) explained that not every professor can be a good mentor. "Mentoring does not come from a guidebook, a set of rules, or even incentives. Mentoring comes from the heart" (p. 410).

Undergraduate research. Institutions have sought to improve the faculty-student relationship through undergraduate research experiences. The National Science Foundation and several other agencies provide funding to support initiatives that organize learning opportunities for undergraduate STEM students within the research laboratory (Erbes, 2008). The apprenticeship experiences offer learners the opportunity to collaborate with scientists, post-doctoral researchers, laboratory technicians and faculty (Sadler & McKinneym, 2010). The undergraduate students design experimental protocols, collect and analyze data, and "apply classroom knowledge to real world problems" (Eagan et al, 2010, p. 152). Through undergraduate scientific research experiences, learners have the opportunity to make close faculty connections (Sadler & McKinney, 2010). Preliminary program evaluation results suggested

improved retention and persistence in the STEM disciplines.
Student Retention Factors

Sternberg (2013) published a list of 12 risk factors associated with student attrition in college. Adapting these findings to sort by intrinsic and external concerns can offer faculty members a greater understanding of their role in student success. Instructors may directly influence factors including academic goals, connections to campus environments, coursework interest, adapting to the college student role, finances and academic knowledge. Student-centric factors may be more difficult for faculty members to cultivate and develop, including ethical judgment, psychological issues, ability to delay gratification, self-regulatory skills, self-efficacy and resilience, and flexibility. Figure 1 illustrates the possible sorting of Sternberg's factors and the role of faculty influence in attrition.

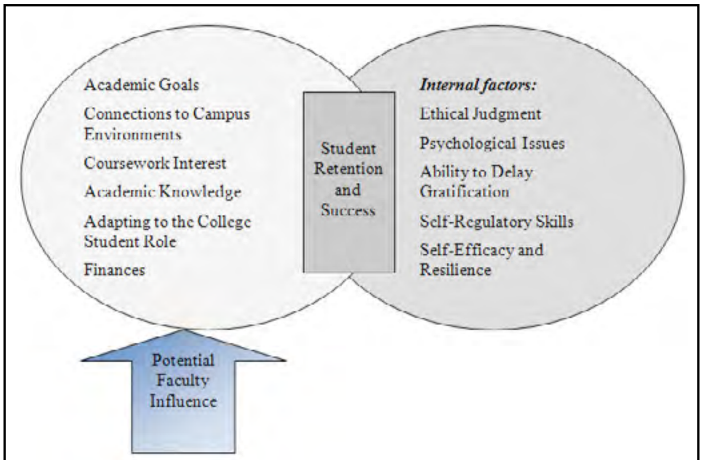

Fig. 1. Student Retention Factors

Discussion and Recommendations

Although some disciplines are successful in the creation of a culture of faculty-student engagement, many of the science, technology, engineering and mathematics (STEM) disciplines engage highly recognized researchers as instructors who often lack deep connections with students (Kokkelenberg, & Sinha, 2010; Seymour & Hewitt, 1997). The culture of STEM education diminishes the importance of the professor-student relationship, shifting focus to the creation of new knowledge through research. Both Hong and Shull (2010) and Vogt (2008) described student-reported feelings of humiliation by professors, suggesting that professors "just did not care about teaching [students] even though students were serious about learning and were willing to put forth effort" (Hong & Shull, 2010, p. 275). Many STEM programs lack the knowledge, tools or administrative support to alter the prevailing lack-of-caring paradigm.
Connecting Faculty to Retention Efforts

Powers (2004) called for a movement to include faculty members in retention efforts. She suggested that, "if faculty buy into the premise that their role is critical, then they seem to be much more open to talking about how we might improve things" (p. 6). The long-standing conflict between the institutional goals of research and teaching may contribute to the diminished professor-student relationship in STEM disciplines. Institutions seeking to increase their STEM retention and graduation rates may need to promote improved awareness of the role of faculty members in this mission.

Shifting professors from a culture encouraging attrition to promote survival of the fittest into a caring and nurturing culture takes effort and specific action ideas. Examination of the characteristics of positive one-on-one relationships can promote faculty perspectives that may result in caring relationships. Wilson, Ryan and Pugh (2010) developed a rapport scale that could offer quantifiable evidence should it be implemented. The qualities examined in the survey instrument characterize the optimal student-professor connection, exploring instructor qualities and behaviors. Some positive faculty member qualities included in the scale are thoughtful, enthusiastic, respectful, understandable, eager, compassionate, fair, reliable, confident, helpful, and friendly. Actions that promote rapport included availability via email, encourages class discussions, goes over material if students are struggling, provides examples, encourages questions, sets clear expectations, and is approachable during office hours.

Exploring the Professor-Student Relationship

Handbooks to guide college professors in teaching explore syllabus construction, classroom management and other mechanics of teaching. However, the majority of books completely avoid the subject of the instructor-student relationship and its importance to student success (Badger, 2008; Groccia, 2012; Johnson, 1995; Miller, 1997). Mastascusa, Snyder and Hoyt (2011) created a guidebook for STEM educators, seeking to encourage awareness of the learning process. However, the discussion of student engagement is limited to classroom activities and techniques. As a result, even when institutions encourage faculty to improve their teaching, instructors may completely miss important qualities that will improve student learning: approachability, empathy, enthusiasm and helpfulness.

Professing, explained by McWilliam (2008) as the art of college instruction, is a one-way flow of discipline-specific information. Instructors convey information in a highly serious and scholarly environment. Professors speak and students listen. Many faculty members will explain this pedagogical approach worked for them and the style should be successful for future generations. Unfortunately, "the digital world has seen the democratization of design and information access" (McWilliam, 2008, p. 267). The conveyer of information can be a computer screen and, as a result, students and teaching have changed. McWilliam (2008) suggested that instructors must relearn how to interact with students, undoing the patterns they observed as undergraduates, and venturing into the role of "useful coworker" and "collaborative critic" (p. 263).

The Classroom Experience

Active learning teaching techniques have shown positive correlation to persistence, retention and satisfaction in the discipline (Braxton, Milem, & Sullivan, 2000). To guide the evolution from traditional lecture to an energized classroom, Barkley (2010) authored a handbook for faculty that explored student engagement in the classroom. In addition to teaching tips and techniques, the author encouraged professors to connect with their students, displaying feelings of interest and enthusiasm. Barkley asked instructors to establish "supportive relationships" with students and to diminish learner "fear of embarrassment" (p.10).

Conclusions

Perhaps instead of another scholarly study of STEM climate, it is time for a call to action, encouraging professors who are accountable to students, display positive learner-rapport, and are held to high standards as caring and compassionate educators. Whitaker (2011) encouraged educators to make it "cool to care" (p. 114). He recommended that professors treat everyone with dignity and respect. Essentially, Whitaker recommended the embodiment of compassion. However, instructors who consider themselves the "sage on the stage" may struggle to display empathy for their students (McWilliam, 2008, p. 263).

Bain's (2004) research and resulting book documented the characteristics of good professors. He summed up the displayed attitudes and behaviors of excellent instructors, explaining, "they tend to treat students with what only can be described as simple decency" (p. 18). The compassion and kindness transcended personality type, such as assertive or restrained, and gender. His observations suggested that treatment of students by faculty plays an important role in the success of learners.

Strong scholarly evidence supports an approach to retention that encourages professors to connect to their students, offering a supportive and warm learning environment. The characterization of a chilly climate must be replaced with faculty enthusiasm and compassion for learner success. STEM employers seek an increase in graduates who can support the global economic competitiveness. Faculty members play a key role in attrition and retention, far beyond the confines of lecture notes and exams. STEM disciplines must drive a change in academic culture away from survival of the fittest to a nurturing experience that supports achievement.

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