The exclusionary affect of biased rhetoric and passive teaching styles used by faculty in undergraduate STEM courses on females and underrepresented minorities

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A STUDY OF UNDERGRADUATE CLASSROOM CULTURE IN STEM FIELDS

The exclusionary affect of biased rhetoric and passive teaching styles used by faculty in undergraduate STEM courses on females and underrepresented minorities

Presented to the Honors Program
in partial fulfillment of the requirements for the
University Honors Program

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Laramie, Wyoming
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Abstract

Research suggests that the culture in gateway undergraduate STEM classes does not promote an environment in which students feel welcome to ask questions and actively participate in the learning process. It has been observed that rhetoric used in these classrooms negatively affects underrepresented students in these fields. Gender and racial biases further play a negative role in whether or not students feel welcome in their STEM department (Malcom, 2016).

Overall, the pervasive culture of undergraduate STEM education appears to ineffectively gauge student understanding due to stereotypes and unproductive rhetoric that affects student retention and ultimate success in the field. Through the use of WyoCast classroom observations we were able to assess the ways in which exclusion is promoted through the use of ineffective rhetoric and passive teaching strategies. Additionally, the University of Wyoming’s STEP tutors were voluntarily asked to participate in a survey. The survey sought to evaluate the ways in which tutors, people who learn and teach, use their own personal experiences to implement strategies that encourage active learning, inclusion and student success. The results of this research indicate that classrooms that integrated higher-order thinking questions, longer wait-time and more interactive activities showed more student participation overall. Underrepresented minorities and females who already feel the pressures of societal biases are more likely to succeed in such environments that encourage active learning and critical thinking. With the growing need for STEM majors in the job market today, it is of inherent interest to provide the best possible learning environment for students as to ensure the highest retention and enjoyment in such programs.

Introduction

Strong evidence suggests that active and collaborative learning allows for a more inclusive classroom environment, thereby encouraging students to feel comfortable participating and speaking up when they need help. Without avenues for engagement, certain underrepresented groups in STEM fields feel further excluded from the course (Malcom). This exclusion affects their ability to retain information and ultimately succeed in undergraduate gateway STEM courses. Shirley Malcom, Chair of the Committee on Barriers and Opportunities in Completely 2-Year and 4-Year STEM Degrees discussed the obstacles that many underrepresented groups face while pursuing a STEM field in 2016. She wrote, “Today women are the majority of students in higher education. The shifting demographic means that the nation has to develop talent from across society including among those who may not in the past …had expectation for success in STEM fields,” (Malcom, ix).

These obstacles that women and minority groups face while pursuing a career in a STEM field are multi-faceted. The national STEM report of 2016 laid out a variety of factors that hindered student success in STEM fields. First, the normative culture that is inherent in most undergraduate STEM fields deems student success as being of innate ability. In other words, students begin to feel a sense of inadequacy if they were not always “gifted” in a STEM field, something referred to as “the fixed mindset” (Dweck). This mentality further hurts their success because students begin to feel that even with a sincere amount of effort, the ability to do well is only one that is inherent and cannot be obtained. Furthermore, it is found that fields where professionals promote the belief in innate talent tend to have less women and minorities (Malcom, 3-3). The report further delves into the competitive culture of undergraduate STEM courses. These so-called “gatekeeper” courses “serve to discourage students who are new to the
field, especially women and those from minority backgrounds,” (Malcom, S-1). Throughout my undergraduate career, pursuing a major in a STEM field while simultaneously tutoring for STEM courses, I have encountered this multiple times. Often students interested in the STEM field are discouraged earlier on in their course studies, as they simply cannot pass general science courses. Even though a plethora of resources are available for student success, they serve no value if students lack the confidence to seek help, as they feel inferior to other students – a mindset promoted by a highly competitive environment. In Our Underachieving College (2006), Derek Bok explains how these weed-out classes are supposed to serve as foundational courses but ultimately end up encompassing too much information that is not “necessary for a basic understanding of the field” (Baldwin, 11). Sadly then, these students at an early start in their STEM career transfer to a non-STEM field as a result of feeling out of place and inadequate.

**Literature Review**

So how many students really do leave STEM degree programs? While degree retention appears to vary significantly across programs, race, gender and institution, life sciences and engineering programs appear to retain their students the best compared to other programs. Thirty-seven percent life science, 39 percent engineering and 36 percent mathematics majors complete their degree in 6 years with only 6 percent life science and 8 percent engineering and mathematics majors switching to a different degree program. Meanwhile, less than 25 percent of physical science majors complete their degree program, with 20 percent switching to a different STEM field and 30 percent switching to a non-STEM field (Malcom, 2-6). Multiple factors contribute to degree completion; one significant factor mentioned in the national STEM report is the longer amount of time it is taking for students to complete a STEM degree, the average being close to six years. While only 22 percent of people wishing to earn a STEM degree in four years
actually complete their goal. The report presented that Asian Americans completed 4-, 5- and 6-year STEM degrees fastest, with a 52 percent completion rate as compared to 43 percent of white aspirants, 29 percent of Hispanic aspirants, 25 percent of American Indian aspirants, and 22 percent of black aspirants earning a STEM degree in 6 years. Further, the 4-year completion rate was 23 percent for women compared to 21 percent for men, but the rate dropped for women after 6 years (38 percent women and 43 percent men) (Malcom, 2-6).

What explains the drop rates among underrepresented minority groups and women in STEM fields? One major contributor is the use of community colleges. It is found that students from minority groups tend to be “concentrated in community colleges, less selective 4-year institutions and for-profit institutions” (Malcom, 2-3). Unfortunately though, an undergraduate’s likelihood of completing a 4-year degree program is much lower if the student starts his or her postsecondary education at a community college versus a 4-year institution. There are a number of factors that contribute to this outcome, one being the difficulty students have when transferring from a community college to a 4-year institution. One review of state-wide policies in four states concluded that four things were key in promoting student success, those being: a common educational core curriculum, common lower-division courses, a focus on credit applicability and an emphasis on junior status upon transfer from an associate program. With
state policies focused on these areas, student transfers and student preparedness for upper-
division work improved. Additionally degree completion rates in 4-year programs increased in
two of the four states, especially for underrepresented groups (Malcom, 5-5). While a multitude
of factors influence degree completion, it is important to recognize where institutional changes
can and should be made in order to make completion of a program focused on the education and
not bogged down by logistical issues.

Another major obstacle facing women and underrepresented groups is the fear of
“stereotype threat.” This threat relates to an individual’s fear of being judged based on views
similar to group stereotypes. Research has shown that stereotype threat significantly impacts an
individual’s ability to do well in an academic setting. In fact, this perception of stigmatization is
a very real part of classrooms rather than just a perception. Stereotype threat leads students to
further disengage their personal identity from their academics out of fear that they will indirectly
affirm a stereotype – something that can negatively impact their success as their academic sense
of ownership can easily dissipate. As explained in the STEM report, if a student continues to
associate stereotype threat with the STEM major, the student will eventually “dis-identify” with
STEM, and ultimately lead he or she to seek a different degree program (Malcom).

Lastly, “benign-racism” or “benign sexism” refers to a professor/mentor interacting with
students of different cultures or genders in a way that is consistent with biases towards a group.
When engaging with a female or a student from an underrepresented group, instead of giving that
student tough, honest and constructive feedback, the professor is vague and praises in an effort to
be overly supportive and avoid offending or hurting a student’s esteem. The professor can also
make an effort to avoid such interactions all together. For example, in the classroom, teachers
tend to interact more with male students than with female students, while using positive
interaction techniques with whites compared to Blacks or Hispanics. Further, research shows that when girls are called on in class there is a greater likelihood they will be asked an easy question compared to a difficult one (Ruggs, 2). Consequently, women and underrepresented groups are not encouraged to think critically the way other students are, as they realize that the professor’s perception of their ability is low. Such behavior from a mentor is grounded in biases towards a group and further hinders a student’s willingness to engage meaningfully in the learning experience (Malcom, 3-6).

Project STEP-UP (STEM Trends in Enrollment and Persistence for Underrepresented Populations) was developed to further explore the specific marginalization that women and underrepresented minority groups face in STEM fields. This project conducted interviews with administrators of STEM intervention programs across many colleges in order to learn about student services offered. The results of the interviews that were conducted over the course of three years drew the overarching conclusion that administration of STEM programs look at women and minorities “through a deficit lens” (Castro, 2). This mentality bleeds over into the language in which such administrators use to describe students from such groups as being “fixed”, “at-risk” or “underprepared.” These perspectives are ultimately supported by biased and discriminatory theories such as the cultural deprivation theory. This theory is embedded in the ideology that student deficits are a result of an “impoverished culture, which causes the victimized person to suffer,” (Castro, 3). Such thinking promotes the systemic oppression of women and minority groups as this theory essentially places blame on individual shortcomings as a result of cultural circumstance, rather than on a discriminatory society (Castro, 3). Putting such thinking in an educational setting continues to hinder student success as students from underrepresented groups are immediately labeled in the eyes of administrators.
This so-called “educational deficit thinking” manifests itself in the form of labeling students from underrepresented groups as being “underprepared.” When administrators were interviewed with project STEP-UP, many of them used language that hinted, if not outwardly said, that students lacked the necessary preparation. One administrator stated, “So while we see underrepresented students certainly at all academic levels…a disproportionate number are underprepared,” (Castro, 4). Some administrators chose to focus on the institutions from which these students came, explaining that they may not have provided the same opportunities or quality of education as compared to others. This justification shifts the burden and blame away from the students and recognizes the shortcomings as being a product of poor institutional policy instead. Further, using the term “at-risk” to describe such students is one that brings with it significant negative connotations. Some administrators described these students at being “at-risk” for leaving STEM programs. Again, this mentality further puts the blame on the students: “The program, major, department, college or university is not ‘at-risk’ for failing a student or for losing a student, but instead, the attention for possible failure applies only to the student,” (Casto, 5). Shifting the burden to the institution to amend educational policies is only half of the battle in seeking change. The other half lies in helping teach administrators and faculty to be mindful of the language which they choose to use and give them a better understanding of what environment they actually are promoting in their classroom.

Differential treatment, negative biases and poor institutional policies can all promote an exclusive learning environment that further hinders success for women and minorities in STEM. As a result of this inherent culture seen in STEM fields, I sought to discover how inclusion and cultural diversity could be accomplished in a classroom setting. Creating an inclusive, engaging
and intellectually stimulating classroom requires multiple factors to be changed within the
typical STEM classroom.

The first major contributor to participation and higher-order thinking from students is a
teacher’s questioning techniques. Bloom’s Taxonomy of higher-level questioning provides a
foundation for the type of questions that promote higher order thinking. A major problem I have
encountered as a student in the undergraduate classroom is professors asking questions that do
not truly promote active thinking. Bloom supported the idea that higher-level thinking only is
truly achieved with higher-level questioning (Watson, 2). Bloom’s Taxonomy is broken down
into six levels of questioning. The lowest level of questioning being knowledge based; these
questions require one to recall information in the form of labeling, listing, naming or stating.

Next, comprehension questions are grounded in a student’s ability to discuss, explain or provide
proof for a concept. Building on comprehension questions are application, analysis, synthesis
and then evaluation questions. Bloom stated that the first three levels of questions were “low-
order thinking, or content” whereas the last three promoted higher-level thinking. Using higher-
level questioning techniques promotes students to think why instead of just regurgitate an
answer. However, effective questioning takes time and planning ahead on a teacher’s part is
essential in order to provide a variety of questions to the students. Teachers who fail to plan
ahead resort to convergent questions that ultimately lessen student engagement and fail to
adequately measure their retention of material (Critelli & Tritapoe, 3).

Ineffective questions commonly used in the classroom discourage students from actively
contributing to classroom discussion and allow them to be passive rather than active learners.
Asking “does everyone understand?” or “any other questions?” prevents students from
measuring their own understanding, and often students do not even respond to questions like this.
Further, asking too vague or too loaded of questions will keep students from feeling comfortable responding. Asking yes/no questions is acceptable when drawing upon previously learned knowledge, however it is ineffective when asking if students understand the material. Rather, classroom assessment techniques such as short quizzes, text-in responses or Clickers should be used frequently during class to assess understanding (Questioning). Additionally, teachers do not have to be the only ones doing the questioning. Allowing students to create their own questions for exams, quiz their neighbor or write down any remaining questions they still have after class can further encourage students to assess their learning while staying engaged. Lastly, encouraging interdependent group collaboration increases self-esteem, morale and breaks down minority barriers. Also, when requiring each member of the group to do something differently it helps “minority students improve academic performance, while preventing feelings of isolation (Ruggs, 7).

Another common factor that affects student engagement is wait time. Wait-time is defined as the amount of time that the teacher allows for students to respond to a question that he or she poses. While it is stressed to keep a quick learning pace in order to keep student interest, it is also essential to slightly slow down material in order to promote achievement. The average wait-time as seen in the classroom is one second or less. Further, “students perceived as slow or poor learners were afforded less wait-time than students viewed as more capable,” (Questioning). Research shows that this wait-time is insufficient for students, especially those who may need further clarification with difficult material. For lower-order questions, a three second wait-time is most effective for student achievement. Students also seem to become more engaged the longer the teacher waited for a response rather than the teacher just answering her/his own question. Overall, increasing wait-time correlated with improved student success, more critical-thinking
responses and more peer interaction among students. All of these outcomes are positive in encouraging an inclusive learning environment.

Research shows that feedback once a student has responded to a question is just as essential as the questioning process itself. When professors provide superficial or vague feedback such as “good” or “that’s not right” he or she discourage students from probing into their answers and shows a lack of investment in student success. It is essential that professors probe students with questions like “why do you think that?” while also acknowledging when a student gets a correct answer. Positive student reinforcement, while using praise sincerely and sparingly, is necessary when encouraging students to participate in class.

All of these teaching techniques, and many more, promote active learning. Active learning is one aspect shown to positively enforce an inclusive classroom. Another contributor to promoting a comfortable and welcoming learning environment is building rapport between a professor and his or her students. Building relationships and understanding issues that may affect students from diverse backgrounds is essential in demonstrating that a professor is truly invested in student success. It is not always easy in big lecture halls to know every student’s name, however, having students write a brief autobiography at the beginning of the semester is one way to show interest and maybe look at the learning background that each student is coming from (Saunders & Kardia, 5).

An appreciation for the benefits that accompany the promotion of an inclusive and culturally diverse classroom, free of assumptions and biases, is crucial as STEM fields move forward in adopting change. Today’s typical STEM classroom, especially entry-level classes, is heavily lecture based and requires memorization of facts and formulas in order to do well in class (Baldwin, 10). Research shows that the traditional lecture is ineffective in teaching students
essential concepts needed in advanced classes. Also, it is shown that professors rarely use illustrations to help students understand a concept when presented in a different manner. Further, dialogue is limited in STEM classes and the practical applications of concepts are rarely discussed. As criticized, STEM courses typically require a “cookbook problem solving” approach rather than fully challenging students in order to simulate what will be encountered in their careers (Baldwin, 11).

Unfortunately, amidst all of these statistics that emphasize how ineffective STEM classrooms are in promoting meaningful learning, change continues to be slow. A major problem contributing to slow change is the limited training devoted to teaching STEM faculty how to teach. Additionally, “the faculty evaluation and reward system in place in many higher education institutions also discourages efforts to enhance undergraduate education in STEM fields” (Baldwin, 12). Most of the faculty reward system places a heavy emphasis on research, thus requiring faculty members to devote a large amount of time to research, publication writing and grant proposals. Unfortunately, there is a lack of incentive for professors to spend time studying the literature behind teaching and learning. On one hand, the autonomy faculty members have when running their own classroom could potentially hinders large-scale change. While on the other hand, this same autonomy allows for genuine, individualized change that meets each classroom’s needs. Many efforts to create a pedagogical learning environment in STEM are carried out by individual faculty members – as I observed even during my time in school. Sadly, no matter how passionate, the “lone wolf approach” may be, it remains insufficient in sparking widespread change, as there are a great number of obstacles, including scientists who outwardly refuse to alter their teaching styles (Baldwin). Perhaps the key is providing institutional incentives to adopt evidence-based teaching practices, while continuing to allow autonomy so
teachers can creatively adapt to such changes. From there, training should be required for STEM professors to learn effective teaching strategies. At an institutional level, reform can possibly be achieved by altering teaching evaluations and observations to better encompass the ideas presented above. If requirements for promotions and tenure are changed as well, then professors will be incentivized to develop their own pedagogical teaching. Such reform would ensure that adoption of new teaching styles is not only widespread, but also lasting.

**Methods**

This research was a two-part project. First, publically available WyoCast courses were observed using an observation tool (Figure One) that was created to analyze the types of questions used in the classroom, the wait time given to students to respond, the use of multimodal learning tools, the way in which classroom understanding is measured, the use of personal response systems and the professor/student interactions on an individual basis. Heavily supported by research, these factors were shown to be major contributors to promoting an inclusive and successful learning environment for all students. Seven undergraduate STEM courses were evaluated including General Biology (Life 1010), Genetics (Life 3050), General Microbiology (Micro 2021), Integrative Physiology (Zoo 4125), Calculus III (Math 2210), General Chemistry (Chem 1000) and Engineering Physics (ES 2210).

The second part of this research involved the University of Wyoming’s STEP Tutoring Center, a widely used resource in which students are able to work one-on-one with tutors. Understanding how to gauge a tutee’s understanding and how to promote learning in an independent and meaningful way for the tutee is a significant part of the tutor training process. This training makes tutors aware of ineffective rhetoric to avoid when tutoring a student. Such rhetoric superficially gauges the retention of a student’s knowledge and ultimately fails to show a
concern for the student’s understanding. For this project, tutors were asked to voluntarily participate in a survey (Figure Two) that evaluated what teaching strategies helped or hindered their success as a student and how the tutors used such strategies when teaching their own students. This research qualified for exempt approval through the IRB office (Protocol # 20161129SW01394). Being that tutors have a unique experience simultaneously serving as both a student and a teacher, it was of interest to evaluate how a tutor’s personal experiences impacted their role as a tutor.
WyoCast Classroom Observation

I. Types of questions asked in the classroom according to Bloom’s Taxonomy:

- The number of the types of questions used in the classroom:
  - Knowledge based (recalling data or information) ______
  - Comprehension based (understanding meaning) ______
  - Application based (use a concept in a new situation) ______
  - Analysis based (distinguish between facts and inferences) ______
  - Synthesis based (combine parts to form new meaning) ______
  - Evaluation based (make judgments about the value of ideas) ______
- Number of questions asked by students ______

II. Appropriate wait time:
- What was the average wait time the professor allowed for the students to answer questions?
  - 1-2 seconds
  - 3-5 seconds
  - 6-10 seconds
  - > 10 seconds

III. Recognizing the value of multimodal learning:
- Does the instructor use more than one teaching method to explain concepts (i.e. PowerPoint and illustrate on the board)?
- What percentage of the class time is devoted to lecturing? (i.e. 80% of the lecture)
- How much of the time is devoted to interactive group discussion?

III. Gauging understanding:
- Does the professor accept a “yes” or “no” question when asking if students understanding material before moving on
- Does the professor request verbal feedback from students after teaching a concept?

V. Use of personal response systems:
- Is there a use of a classroom assessment system in which the students’ understanding is measured?
  - If so, what kind? (Clickers, quizzes, group discussion over new material)

VI. Knowing students as individuals:
- Does the professor address students by their names?
- Does the professor encourage all students to respond to questions asked?

VII. Overall, does the professor seem approachable and willing to help students when there is misunderstanding?

Figure Two: WyoCast observation checklist used to observe the classrooms of undergraduate STEM courses.
**STEP Tutor Survey**

1. Please circle one:

<table>
<thead>
<tr>
<th>Gender</th>
<th>Class Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>FR SO JR SR GRAD Other</td>
</tr>
<tr>
<td>Female</td>
<td></td>
</tr>
</tbody>
</table>

Age: ______

Do you consider yourself to be part of a minority group? Yes No

2. What is your major?

3. As a student, what modes of learning help you best understand material (i.e. lectures, demonstrations, group activities, etc.)?

4. What do you find is one factor in a classroom that has hindered your ability to succeed?

5. Do you feel comfortable speaking up in your classes when you need help or want to contribute to a discussion? Why or why not? (If you feel comfortable speaking up in some classes but not others please explain why.)

6. For what classes do you tutor?

7. What two strategies do you use that you feel make you a successful tutor?

8. What two factors do you commonly run into that appears to hinder student success in a course? (i.e. not attending class, not comfortable seeking help, etc.)

9. As a tutor, do you find that the way you present material impacts student retention? How?

10. As a tutor, do you find that the way in which you speak to/ask a student questions impacts their ability to feel comfortable asking questions?

11. Overall, what things do you avoid doing/saying when you tutor a student? Why?

**Figure Three:** Survey given to University of Wyoming’s STEP tutors.
Results

78.57% of the total questions asked in all seven course observations fell under Bloom’s classification of knowledge, comprehension or application based (Figure Four). This left 21.43% of questions being high-order in nature and requiring analysis, synthesis and evaluation processes. The number of question types varied with each class, with a larger number of higher-order questions seen in the Physiology (39%), Genetics (43%) and Microbiology (25.8%) courses.

![Number of Questions Presented in Observations Based on Bloom’s Taxonomy](image)

**Figure Four**: The number of questions presented during each WyoCast observation, broken down into Bloom’s Taxonomy of low- versus high-order questions.

58.7% of the combined questions asked in all seven courses, were given a 1-2 second wait-time, whereas 26.2% of questions were given a 3-5 second wait-time. Of all seven courses that were observed, two classes used personal response systems in the form of text-in answers.
and Clicker questions. One of the seven classes did a formal group interactive activity and two of the seven professors used individual names when interacting with students (Table One).

![Wait-Time Alloted Per Question In Each Classroom During Observation](image)

**Figure Five:** The wait-time per question posed by each professor.

Time spent lecturing consumed an average of 85% of class time, with the exception of one course with lecturing time around 60% instead. Three of the four classes used illustrations on the board or on a tablet to explain a concept after lecturing over it, while two of the four classes used demonstrations to better illustrate a concept. Additionally, all but two professors asked yes/no questions such as “does that make sense?” when gauging student understanding. Of the seven courses observed, three of the four classes had over ten students ask the professor questions, with the other four averaging less than three questions asked per class period. Additionally, four of the seven professors answered their own questions over approximately 50% of the time. The professors observed to answer majority (>50%) of their own questions, on average, provided less wait-time compared to professors who did not.
By the time these data were analyzed, twenty-six STEP tutors submitted a survey. This equated to over a 50% response rate. Of the respondents, 50% were females and 50% were males, with 88.4% of the respondents being of junior or higher standing in their coursework. 96.2% of the respondents were STEM majors, and all but two of the respondents tutored for a STEM course.

<table>
<thead>
<tr>
<th>Number of Classes (out of seven)</th>
<th>&gt; 70% of class time devoted to lecture</th>
<th>Uses personal response systems</th>
<th>Requires group activity work</th>
<th>Professor uses student names during interaction</th>
<th>Professor illustrates points on the board, overhead, etc.</th>
<th>Professor answers his/her own questions &gt;50% of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Table One:** Number of classes broken down according to behavior seen during WyoCast observations.

When asked what modes of learning help the tutors learn best as students, 28% of students prefer hands-on projects and group activities, 28% prefer example problems and 25.7% prefer demonstrations (Figure Six). This left 11.4% preferring self-study and only 5.7% preferring traditional lectures. Of the classroom aspects to most hinder student success, 48.4% of respondents said passive learning/lectures, unorganized lectures and a lack of sincere interest on the professor’s part were most discouraging. Many of the other aspects to negatively affect student success fell under categories including distractions (19.3%), lack of application of material presented (16.1%), memorization of too much material/regurgitative learning (12.9%) and not attending class (3.2%).

When respondents were asked if they feel comfortable speaking up in

**Figure Six:** Learning styles preferred by STEP tutors, from a student perspective.
class, 26.9% stated no, 23% stated yes and 50% stated sometimes. Most tutors noted that they feel more comfortable speaking up in small settings (discussion or office hours) rather than during lecture, speaking up when the professor knows their name and speaking up when they are more confident in their response, as to avoid looking uneducated. Other factors that contributed to a lack of student contribution in the class included age and nervousness, with some tutors noting that feeling as one of the youngest students deters them from contributing to lecture. Additionally, some respondents stated that a perceived lack of interest in receiving student feedback from the professor keeps them from speaking up. Of the six respondents to note that they do feel comfortable speaking up in class regardless of varying circumstances, four of them were graduate students. Most of these students noted that they likely feel more comfortable to speak up in class because they are older or have a more outgoing personality.

The most successful strategies tutors stated they use when teaching students included: asking effective questions/not giving answers right away (21.2%), getting to know student backgrounds so as to better cater to different learning styles (21.2%), having students illustrate concepts (17.0%), being personable and using positive reinforcement (17.0%), using real world examples/application of material (14.9%), and reviewing fundamentals while summarizing learned material at the end of tutoring sessions (8.5%) (Figure Seven). Furthermore, when asked if the tutors thought that the way they presented material affected student retention and understanding, 92.3% stated that it

![Figure Seven: Top strategies used by STEP tutors when teaching students.](image-url)
did. When asked what things they try to avoid saying/doing when tutoring students, most respondents stated that they avoid saying an answer is incorrect so as to not discourage students from feeling confident in sharing their thoughts/answers (31.4%). Respondents also stated that they avoid giving students answers without questioning them (17%), saying a concept is easy (14%), being impatient (14%), allowing students to speaking negatively about themselves (11.4%) and saying statements like “does that make sense?” (11.4%).

When tutors were asked what factors they thought greatly hinder student success from a teaching standpoint, respondents provided the following explanations: procrastination (29.5%), not doing assignments/attending class (25%), lack of confidence in class (15.9%), uncomfortable asking professor questions (13.6%) and not using resources such as notes or supplemental instruction (13.6%).

![Factors Hindering Student Success](image)

**Figure Eight:** Factors that hinder student success from the STEP tutors’ perspectives.

Lastly, tutors were asked if they felt that the way they speak to students/ask questions impacts the student’s ability to feel comfortable asking the tutor questions. 100% of the respondents agreed with this statement. Most tutors provided additional insight, stating that using a friendly tone of voice and avoiding the use of judgmental or condescending statements made tutoring sessions more comfortable for both the tutor and the student. Additionally, tutors stated that using open-
ended questions appeared to elicit more responses from students as it kept them more engaged in what was being asked.

**Discussion**

This research was conducted to evaluate the techniques used by professors in creating an inclusive classroom environment that better ensures student success and retention in undergraduate STEM fields. Observing the seven undergraduate STEM courses via WyoCast was done in an effort to non-invasively evaluate real-time teaching here at the University of Wyoming. Majority of the classrooms used knowledge and understanding based questions when gauging student understanding of material. The high number of low-level questions asked in most classrooms likely indicates that students are not being challenged, nor is their understanding and application of material truly being evaluated. This leads to a huge disconnect between teaching and learning. The importance of effective questioning was something many STEP tutors made mention of as well. This supports heavy research indicating that thought-provoking questions are not only crucial in developing higher-order thinking skills, but are also preferred by students.

Being that these classes predominantly are taught using lecture-based methods, this further hinders student engagement and understanding, thus creating an exclusionary environment in which females and underrepresented minorities feel further disconnected from the classroom. These teaching methods are ineffective for all students as they promote a heavily competitive and unwelcoming atmosphere. Such an environment can be detrimental for students already facing issues such as stereotype threat and benign racism or sexism, as they feel unable to speak up in an already exclusionary classroom. With better application of multimodal learning
tools and higher-order questioning, students would be more empowered to seek help and take part in the learning process — something that is not accomplished with passive teaching styles.

Classrooms that did interactive work on the board only received student input when the professor did not give answers and allowed for a greater wait-time on average (> 3-5 seconds). When professors gave the answers immediately, or worked out problems on the board independent of the students’ involvement, the classroom appeared to have a substantially lower level of participation. Often times, questions are thrown at students without allowing sufficient wait-time for processing. Allotting such little response time hurts even the highest participating student in class. So for females and underrepresented minorities, this continues to make classroom participation uncomfortable. These findings indicate that allowing students the time to process the questions being asked better promotes class participation. If critical thinking questions are being integrated into the lesson plan, then allowing for a longer wait-time is essential in ensuring student engagement, while giving them a full understanding of what is being asked.

Personal response systems can be used to gauge student understanding, but also to receive raw, anonymous feedback from students that a professor might not receive otherwise. One professor had a text-in response system displayed at the beginning of the class that asked students what they still are having trouble with and what they would like to see answered in the review prior to the test. The professor received many text-in responses. This not only gave the professor a better idea of what to spend more time on in the review, but it also gave an avenue for all the students to evaluate their understanding and explain their struggles without concern for peer or professor judgment. This heavily supports existing literature that shows that personal response systems increase participation and decrease student anxiety by eliminating the fear of
criticism or rejection (Ruggs & Hebl). This is extremely useful, especially in classrooms that are highly competitive; a characteristic trademark to the typical undergraduate STEM courses. Additionally, personal response systems further keep the class engaged in the material. If a small amount of points is allotted to answering questions provided during class it further incentivizes students to attend and keeps them more attentive to the material. The incorporation of personal response systems would not only increase student engagement, but would also help professors better spend their time focusing on areas where many students are struggling. This would further benefit students, as most professors only acknowledge areas of confusion after an exam, which at that point has already negatively affected students’ grades.

When professors used illustrations, demonstrations or group activates, there was an overall increase in classroom participation. By using multi-modal learning techniques, professors are better able to encourage class participation by integrating interactive lessons and requiring higher-order thinking from the students. Also, this steers professors away from heavy lecturing, which has been shown to be highly ineffective in retention of fundamental concepts for students. Lastly, the professors who used student names had a higher level of class participation. This is typically correlated with a greater interest in student backgrounds, which aids in creating an environment in which all students feel comfortable.

The STEP Tutoring surveys were done to evaluate how tutors use their own personal experiences to better teach their own students. The results from the survey indicated that tutors show a significant preference for interactive, multimodal, inclusive teaching styles when placed in a classroom. Most respondents strongly dislike passive learning without being given some form of application of material being taught. Illustrations, demonstrations and examples were the highest favored form of learning. A lack of engaging learning techniques can often lead students
to feel a sense of disconnect with the course and the learning process as a whole. In an environment such as this, females and minorities may feel further discouraged if they are already perceived to be at an academic disadvantage by their peers or professor.

Feeling comfortable speaking up in class or addressing a professor is essential in navigating difficult teaching styles. If a student can at least gain the confidence to ask questions, then he or she can fill in the gaps where a professor may fall short. Sadly though, a vast majority of students still feel discouraged from speaking up in class. All of the respondents to the survey were of junior class standing or higher. In other words, these students are, or should be, at a point where they feel comfortable enough to ask questions with moderate confidence. However, only six respondents stated that they absolutely are comfortable speaking up, four of which are graduate students. Most students expressed that they felt more comfortable speaking up in classrooms that were smaller; around people they knew better and in front of professors who appeared more responsive to student feedback. This finding further supports the idea that a positive, encouraging environment enhances student participation as supported by Saunders and Kardia in “Creating Inclusive College Classrooms.”

As expected, tutors use teaching strategies that they prefer as students when teaching tutees. Tutors use interactive disciplines such as videos, illustrations and examples when trying to explain a concept. Most tutors noted that they try to get a better understanding of student backgrounds and exposure to material in order to cater their tutoring towards a student’s learning preferences. While this is not always realistic in a large classroom, it is something that can be accomplished when more than one mode of teaching is incorporated into a lesson. Tutors also place a huge emphasis on the importance of effective questioning. By asking questions that evoke critical thought, such as “why does this work this way?” students are required to do more
than just regurgitate a memorized answer. Additionally, tutors stated that giving students the answer hurts a student’s ability to figure an answer out of their own. This is something that should seem quite intuitive, and yet a number of professors continue to pose questions and answer them on their own with minimal wait-time.

All of the tutors agree that the way they speak to students impacts the students’ ability to feel comfortable asking questions. This acknowledges the fact that building rapport with students by showing an interest in their background and using a positive tone of voice can affect a student’s willingness to interact in an academic environment.

Overall, these research findings reinforce how the normative undergraduate culture in STEM classes can negatively affect class participation and engagement. Without avenues for interaction, students who already feel marginalized continue to be less encouraged to seek help. Without the confidence, these students fail to seek out help and resources necessary to pass these “gatekeeper” courses.

So where do we go from here? Unfortunately, change is extremely slow despite a vast amount of research supporting the ineffectiveness with which these entry-level courses are taught. Providing time for faculty to receive formal pedagogical training would possibly be a solution. While some professors may still seem resistant to modifying their teaching curriculum, making institutional mandates could possibly circumvent this issue. If the faculty reward system placed less emphasis on research this could potentially allow for more time to be allotted towards teaching training programs. All in all, systemic change is needed in order to provide a permanent solution to the growing problem. Retention in STEM fields is essential for a variety of reasons. Most importantly, it is unfortunate to see students who are genuinely interested in STEM end up leaving their degree program due to avoidable problems. Ample research supports the positive
affects of interactive and engaging learning in regards to student retention, understanding and overall enjoyment in their program. While the unique style of each professor, department and institution adds to the college experience, at some point, steps need to be taken in an effort to bridge the disconnect between so many females and underrepresented minorities and their respective STEM educations. Programs like the University of Wyoming’s Science Initiative Task Force and the Learning Actively Mentoring Program (LAMP) have been implemented in an effort to bridge this gap. One of the most important goals of the LAMP program includes training STEM faculty on how to use interactive teaching strategies. LAMP’s theme for the summer of 2017 is “Active Learning: The Pedagogy of Inclusion.” By providing such training, the programs hope to see a decrease in student failure rates by increasing inclusion through student engagement, diversity and motivation. The Science Initiative is further dedicated to providing large-scale active learning facilities in which many students can engage in hands-on research. Measures such as the Science Initiative and LAMP program impeccably encompass and address the concerns revolving STEM fields. These programs have the potential to apply systematic change in a practical and realistic manner. Overall, students will be more likely to remain committed to a STEM field when classrooms better strive to use inclusive techniques that promote thoughtful and interactive learning.
Sources


