ABSTRACT This study investigated differences between STEM and non-STEM classes in instructor selection of course objectives and student self-perceptions of learning, motivation, and work habits, as well as student ratings of teaching and the course. STEM instructors employ teaching methods strongly associated with student progress on the learning objectives they emphasize. Moreover, students report the greatest progress on those objectives. However, students in STEM classes report making less progress than non-STEM on relevant learning objectives.

Which learning outcomes and teaching methods are instructors really emphasizing in STEM courses?

Steve Benton, Ron Brown, Dan Li / The IDEA Center

Statement of the Problem

The need to develop student capabilities in science, technology, engineering, and mathematics (STEM) is well documented. Nonetheless, many capable college students either do not pursue or eventually drop out of STEM majors. Attrition in STEM has been attributed to instructor reliance on lecture and failure to engage students in active learning (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). Introductory STEM courses focus too much on acquiring content knowledge and too little on critical thinking (Handelsman et al., 2004). The current study investigated differences between STEM and non-STEM classes in instructor selection of course objectives and student self-perceptions of learning, motivation, and work habits, as well as student ratings of teaching and the course.

Method

Archived data were analyzed from student ratings collected in 283,176 undergraduate (89%) and graduate (11%) STEM classes from 2007-2011 in all regions of the continental U.S. These were compared with ratings in 1,800,013 non-STEM classes. Approximately 40% of institutions were master's level, 20% bachelors, 20% doctoral, 5% associate, and 5% other. STEM classes included 45% science, 28% math, 14% computer science, and 13% engineering.

Students completed The IDEA Center's Student Ratings of Instruction Diagnostic Form. Faculty completed the IDEA Faculty Information Form. See the forms at http://www.theideacenter.org/services/student-ratings/sample-forms-student-ratings-instruction. Technical information may be found at http://www.theideacenter.org/sites/default/files/techreport-12.pdf

Learning objectives

1. Gaining factual knowledge (terminology, classifications, methods, trends)
2. Learning fundamental principles, generalizations, or theories
3. Learning to apply course material (to improve thinking, problem solving, and decisions)
4. Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course
5. Acquiring skills in working with others as a member of a team
6. Developing creative capacities (writing, inventing, designing, performing in art, music, drama, etc.)
7. Gaining a broader understanding and appreciation of intellectual/cultural activity (music, science, literature, etc.)
8. Developing skill in expression myself orally or in writing
9. Learning how to find and use resources for answering questions or solving problems.
10. Developing a clearer understanding of, and commitment to, personal values
11. Learning to analyze and critically evaluate ideas, arguments, and points of view
12. Acquiring an interest in learning more by asking my own questions and seeking answers

Student Characteristics

Student Motivation
38. I really wanted to take a course from this instructor.
39. I really wanted to take this course regardless of who taught it.
40. Students' level of enthusiasm for the course (faculty response)

Student Work Habits & Effort
37. I worked harder on this course than on most courses I have taken.
43. As a rule, I put forth more effort than other students on academic work.
4F. Students' level of preparation for taking the course (faculty response)
4H. Students' level of effort to learn (faculty response)

Summary Ratings

40. As a result of taking this course, I have more positive feelings toward this field of study.
41. Overall, I rate this instructor an excellent teacher.
42. Overall, I rate this course as excellent.

Teaching styles

Stimulating Student Interest
4. Demonstrated the importance and significance of the subject matter
8. Stimulated students to intellectual effort beyond that required by most courses
13. Introduced stimulating ideas about the subject
15. Inspired students to set and achieve goals which really challenged them

Fostering Student Collaboration
5. Formed "teams" or "discussion groups" to facilitate learning
16. Asked students to share ideas and experiences with others whose backgrounds and viewpoints different from their own
18. Asked students to help each other understand ideas or concepts

Establishing Rapport
1. Displayed a personal interest in students and their learning Student-Faculty interaction
2. Found ways to help students answer their own questions.
7. Explained the reasons for criticisms of students' academic performance
20. Encouraged student-faculty interaction outside of class (office visits, phone calls, e-mail, etc.)

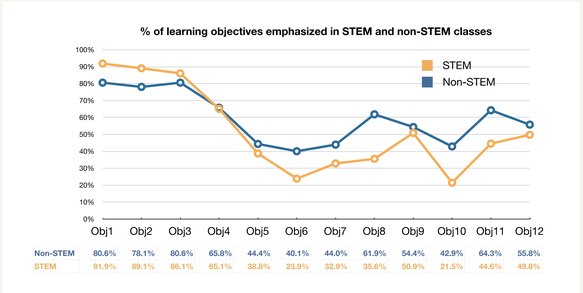
Encouraging Student Involvement
9. Encouraged students to use multiple resources (e.g. Data banks, library holdings, outside experts) to improve understanding
11. Related course material to real life situations
14. Involved students in "hands on" projects such as research, case studies, or "real life" activities
19. Gave projects, test, or assignments that required original or creative thinking

Structuring Classroom Experiences
3. Scheduled course work (class activities, tests, projects) in ways which encouraged students to stay up-to-date in their work
6. Made it clear how each topic fit into the course
10. Explained course material clearly and concisely
12. Gave tests, projects, etc. That covered the most important points of the course
17. Provided timely and frequent feedback on tests, reports, projects, etc. To help students improve.

Results

Which learning objectives are emphasized in STEM classes?

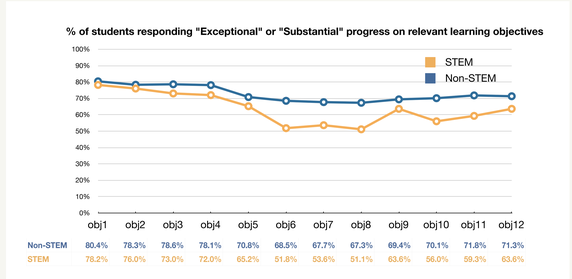
Over 85% of STEM instructors emphasized (i.e., rated as either essential or important to the course), "gaining factual knowledge" (obj1), "learning principles/theories" (obj2), and "applying material to improve thinking and problem solving" (obj3). STEM instructors were less likely than non-STEM ones to emphasize "creativity" (obj6, 24% vs. 40%) and "communication skills" (obj8, 36% vs. 62%).



	Obj1	Obj2	Obj3	Obj4	Obj5	Obj6	Obj7	Obj8	Obj9	Obj10	Obj11	Obj12
Non-STEM	80.6%	78.1%	80.6%	65.8%	44.4%	40.1%	44.0%	61.9%	54.4%	42.9%	64.3%	55.8%
STEM	91.9%	89.1%	86.1%	65.1%	38.8%	23.9%	32.9%	35.6%	50.9%	21.5%	44.6%	49.8%

How much learning are students reporting on those learning objectives?

Students in STEM classes reported less progress on all 12 IDEA learning objectives than those in non-STEM. STEM students reported the greatest progress on objectives the instructor emphasized, the least on those the instructor was least likely to emphasize.

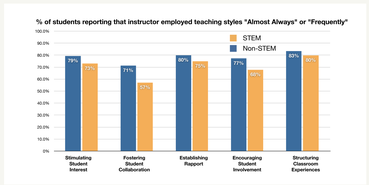


	obj1	obj2	obj3	obj4	obj5	obj6	obj7	obj8	obj9	obj10	obj11	obj12
Non-STEM	80.4%	78.3%	78.6%	78.1%	70.8%	68.5%	67.7%	67.3%	69.4%	70.1%	71.8%	71.3%
STEM	78.2%	76.0%	73.0%	72.0%	65.2%	51.8%	53.6%	51.1%	63.6%	56.0%	59.3%	63.6%

Students in STEM courses reported more positive feelings toward the field of study as a result of taking the courses than those in non-STEM classes.

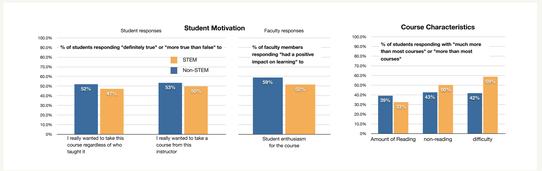
Which teaching methods might be employed to support greater student learning?

STEM instructors consistently used all teaching methods less frequently than did non-STEM instructors. However, in over 70% of STEM classes, instructors employed teaching methods that stimulated student interest, established rapport, and structured the classroom experience, which are highly correlated with the learning objectives they emphasized.

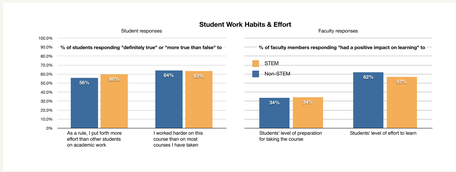


Student and course characteristics in STEM courses

Students in STEM and non-STEM classes reported similar levels of motivation to take the class. However, STEM courses were perceived as more difficult.

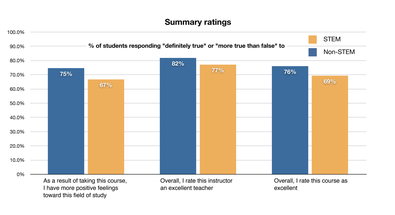


In spite of this, students in STEM courses reported putting forth no more effort than students in non- STEM.



What are summary ratings of STEM courses?

Ratings of the excellence of the teacher and excellence of the course were lower in STEM. More troubling were the consistently lower ratings on attitudes toward the field of study. This has implications for general education classes where many students get their first exposure to STEM.



Conclusion

STEM instructors employ teaching methods strongly associated with student progress on the learning objectives they emphasize. Moreover, students report the greatest progress on those objectives. However, students in STEM classes report making less progress than non-STEM on relevant learning objectives. STEM instructors should increase how frequently they apply appropriate teaching methods, and STEM students should raise their effort level. These findings may have implications for public policy in STEM fields.

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