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Exploring Students' Perspectives of College STEM: An Analysis of Course Rating Websites

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One of the crucial goals of higher education is building a scientifically literate citizenry. The science, technology, engineering, and mathematics (STEM) subject areas are indicated as good domains to develop knowledge and skills for becoming future leaders. However, previous research has indicated a constant decline in the number of American college students enrolled in the STEM areas. Several studies have indicated that instructors play a critical role in promoting students' satisfaction that influences their learning. This study explores the teaching characteristics that influence student satisfaction in college STEM courses through document analysis. The data include students' comments reported on two college course-rating websites. Thematic analysis was used to analyze the data. Four identified instructional attributes pertinent to student satisfaction are as follows: (a) teaching styles, methods, or strategies; (b) teacher knowledge and preparation; (c) teacher attitude toward teaching, subject, and students; and (d) practical workload and expectations. We discuss implications of the study results and future research directions.

Given the fast growing technology in the current era, today's society places a high priority on the cultivation of a diverse science, technology, engineering, and mathematics (STEM) workforce (National Science Board, 2007). Also, all citizens are strongly encouraged to become science- and math-literate in order to maintain a good standard of living (Seymour, 2002). Accordingly, the importance of STEM in higher education has been recognized for a decade. The National Research Council (NRC, 2003) emphasized that undergraduate education is responsible for training future leaders in the STEM areas.

However, numerous reports have expressed concern over the small number of college students who graduate with degrees in the STEM areas. Many college students tend to choose a non-STEM field as their major when they first enter college (Chen & Weko, 2009). What is even worse is that a great portion of students who enter college with an intention to major in STEM areas either change their majors to a non-STEM field or drop out of school. For example, after analyzing data from the national survey of post-secondary students (e.g., NPSAS), Chen and Weko (2009) reported that only 28% of college students who entered in a STEM field continued and attained a bachelor's degree in a STEM field. Similarly, the work of the Higher Education Research Institute (HERI, 2010) has also reported 20% to 50% of student loss rates in college STEM disciplines. All of these studies imply that the current US society is experiencing a dearth of talent in the STEM field.

Although it seems that various issues are related to the loss of students in the STEM area, some studies indicated that the low quality of the college learning environment plays a significant role. For example, Seymour and Hewitt (1997) conducted an ethnographic study with college students across seven institutions and reported no remarkable differences in academic performance or motivation between students who persisted in a STEM field and those who left the field. Rather, students repeatedly reported poor teaching and lack of academic support as a major problem in their STEM courses. Similarly, Smith, Douglas and Cox (2009) suggested that the student attrition rate is more likely to be influenced by students' perceptions of the quality and character of the classroom environment rather than students' abilities. Thus, college students may be leaving the college STEM classrooms due to the low quality of instruction.

Although numerous studies have identified various elements of high quality instruction, they have rarely looked at how the quality of instruction affects students' course satisfaction. Given that instruction should be context-specific (Schulman, 1987), it is likely that certain instructional strategies are more prominent in a college STEM classroom. Furthermore, students in a college STEM classroom probably have different instructional needs when compared to students in different grade-levels and/or in different content areas. Therefore, the current study aims to explore the elements of instruction that have a great influence on the academic experiences of college students in the STEM field. Because the focus of the study was to identify correlates of students' course satisfaction, we examined the quality of instruction particularly from college students' perspectives on their STEM courses. In the following, we summarize the characteristics of quality instruction of college STEM courses reported in the previous research.

Characteristics of Effective Undergraduate Teaching in STEM

With the goal of developing resources to help postsecondary STEM faculty and administrators evaluate teaching effectiveness, a NRC committee has

reviewed and synthesized the research literature on successful standards and practices in college teaching. Based on the review of the literature, the NRC (2003) articulated five characteristics of effective college teaching of STEM: (a) knowledge of subject matter; (b) skill, experience, and creativity with a range of appropriate pedagogies and technologies; (c) understanding of, and skill in using, appropriate assessment practices; (d) professional interactions with students within and beyond the classroom; and (e) involvement with and contributions to one's profession in enhancing teaching and learning. Details of each characteristic are described below.

Knowledge of Subject Matter

The first characteristic of high quality teaching of STEM is sufficient knowledge of the subject matter. College STEM involves more abstract, complex theories and concepts than STEM in K-12. In order to succeed in college STEM courses, students are also required to think more deeply and critically and develop skills of probing, questioning, and integrating information. Only with thorough understanding of the subject matter as well as the sub-disciplines, college instructors can help students develop not only general knowledge about the domain but also problem-solving and critical thinking skills.

Skill, Experience, and Creativity with a Range of Appropriate Pedagogies and Technologies

The NRC committee indicated rich skills, experiences, and creativity with appropriate pedagogies and technologies as another characteristic of effective teaching. Individual students have different learning needs (King & Kitchener, 1994). In order to serve students who are at different levels of understanding, instructors need to use a variety of learning strategies and contextually appropriate pedagogies. College students have demonstrated better learning when their instructors consider multiple instructional strategies (NRC, 2003). For example, combinations of inquiry-based, problem-solving, information-gathering, and didactic forms of instruction have promoted students' conceptual understanding and their abilities to apply knowledge in new situations (Stephans, Dyche, & Beiswenger, 1988). In addition to multiple instructional strategies, the appropriate use and application of information technologies is suggested as an important component of effective teaching of STEM (NRC, 2003). With the pervasive use of different technologies in the current era, the effective ways for technology to improve teaching and learning science has been increasingly discussed (e.g., Guzey & Roehrig, 2009; MacArthur & Jones, 2008; Yang & Tsai, 2010). While the role of information technology in undergraduate classrooms, laboratories, and field environments is an area for continued investigation (e.g., American Association for Higher Education, 1996; Collis & Moonen, 2002; National Institute for Science Education, 1999), the NRC committee emphasized that college STEM instructors have to develop their capabilities to incorporate these technologies in their teaching so that the different needs of students can be better served.

Understanding of, and Skill in, Using Appropriate Assessment Practices

The third characteristic of high quality teaching is appropriate assessment practices. This includes instructors' ability to construct fair and accurate assessments. Assessments should be in accordance with the objectives of a course and longer-range curricular goals. Instructors should only analyze and assess what they have taught to students (Astin, Parrott, Korn, & Sax, 1997). Also, instructors should consistently evaluate students' progress and use these data to improve their teaching. For example, at the beginning of the semester, instructors may assess students' readiness for learning science. Instructors can use the Test of Scientific Literacy Skills (TOSLS; Gormally, Brickman, & Lutz, 2012) or the science motivation questionnaire (Glynn, Taasoobshirazi, & Brickman, 2009) to detect students' motivation for introductory science classes with quantitative results. Use of audience response system (ARS) or *clickers* can be considered as a way to understand students' learning progress during teaching (Caldwell, 2007).

Professional Interactions with Students Within and Beyond the Classroom

The role of instructors is not limited to dissemination of knowledge. Instructors are also responsible for advising and mentoring students. Students are encouraged when their instructors pay attention to their difficulties and willingly offer appropriate support. An important element of effective instruction involves building on students' preconceptions and prior beliefs in ways that help each student achieve a deeper understanding. If students' initial ideas and beliefs are ignored, students may fall far short of the goals of the instructor (Mestre, 1994; Minstrell, 1989; NRC, 2003). By extending instruction to building positive interactions with students, college instructors can demonstrate high quality teaching (NRC, 2003).

Involvement with and Contributions to One's Profession in Enhancing Teaching and Learning

Involvement with, and contribution to, the professional fields are also required to enhance

effective teaching in the STEM disciplines. Scholarly collaborations are increasing within and outside of the departments in science and engineering disciplines (Boyer, 1990; Glassick, Huber, Maeroff, & Boyer, 1997; Kennedy, 1997). As working with colleagues from various disciplines can broaden instructors' own perspectives, their teaching strategies are also likely to improve (Hutchings, 1996; NRC, 1999).

These five characteristics of effective teaching are suggested to provide a learning environment that can improve students' scientific thinking skills. However, scarce studies have explored needs of college students in STEM courses and examined teaching characteristics that are greatly critical for these students. Students' needs may vary depending on their personal learning attributions, learning environments, and majors. For instance, many STEM courses are delivered in large-enrollment classroom settings which force instructors to maintain lecture-driven classrooms and keeps them from providing students with appropriate support due to limited time. Some students may be comfortable with learning in such a large-enrollment classroom, while others prefer a small-size classroom. In particular, students who have less background in STEM may need more individual support and feedback from the instructor (Linn & Eylon, 2006). In terms of learning effectiveness, several studies have indicated that traditional lecture-driven classes, which are thought to be a way of promoting memorization of factual information, may be ineffective for students to learn complex concepts and ideas introduced in science courses (Honan, 2002; Loverude, Kautz, & Heron, 2002; Terenzini, Springer, Yaeger, Pascarella, & Nora, 1996). Thus, without addressing students' distinct needs in STEM courses, lecture-based courses may rather hinder their learning (King, 1994; Loverude et al., 2002; Marchese, 2002; Mestre, 1994). To provide an appropriate learning environment to meet the needs of STEM education, the present study suggests instructors understand learning problems and difficulties that students encounter while learning STEM subjects.

Course Rating Websites as a Valid Channel of Student Perspectives

The five key characteristics of effective teaching described above have been identified in relation to enhanced student learning. However, improvement of student learning alone may not necessarily resolve the problem of student attrition from the STEM fields. Rather, student satisfaction may have a more direct connection with it (Seymour & Heweitt, 1997). Nevertheless, only a few studies have examined college students' satisfaction with their STEM courses. In order to achieve a better understanding about student attrition in college STEM courses, it seems necessary to examine students' perception about course instruction. By doing so, we can extract the critical elements of teaching that have a significant influence on students' attrition from STEM courses.

As a way to explore the effectiveness of teaching and learning from students' perspectives, previous research has relied on standard scales that assess students' experiences of the learning and teaching that they have received (Calvo, Markauskaite, & Trigwell, 2010). The National Survey of Student Engagement (NSSE) in North America (Kuh, 2001), the National Student Survey (NSS) in England (Surridge, 2008) and the Course Experience Questionnaire (CEQ) in Australia (Ramsden, 1991) are a few examples. Yet, these standard-scaled questionnaires focus on measuring the overall satisfaction level of students' learning experience rather than the sources of the satisfaction or impact from teaching (Lizzio, Wilson, & Simons, 2002). Also, the use of standardized questionnaires limits students' responses to the pre-defined constructs.

One study examined students' learning experiences in college engineering classes and quantified their satisfaction about teaching quality over 7 years using a standardized student feedback questionnaire (Calvo et al., 2010). According to this study, students' perceptions of their learning experiences correlated positively with their satisfaction with the quality of the course. For example, students were satisfied with the quality of their subjects in the following circumstances: (a) when the learning outcomes and expected standards were clear to them, (b) when instruction was helpful for them to learn, (c) when they learned valuable skills to be professionals when they graduate, (d) when the assessment allowed them to demonstrate what they have understood, (e) when they could see the relevance of their subject to their degree, (f) when staff were responsive to feedback, (g) when their prior learning prepared them well, (h) when they could understand their teacher, and (i) when the faculty infrastructure was viewed as supportive. However, previous studies used standardized questionnaires which were based on the predefined factors of effective teaching. Although the results were able to quantify the amount of satisfaction on the factors, the study did not address the nature of student satisfaction. Rather than quantifying students' perceptions on effective teaching from pre-defined factors, future research will need to address students' needs and perceptions on effective teaching.

Another study explored how undergraduate students defined excellence in engineering education to develop a better understanding of learners' views and perceptions about effective teaching (Pomales-García & Liu, 2007). Forty-seven undergraduate engineering students responded to questions about excellence in engineering education and participated

in a focus group discussion. The study focused on examining students' perspectives on the roles of students and professor, goals of and challenges with teaching engineering, and effective methods of teaching engineering. The study results showed that students recognized the importance of their active involvement in learning and appreciated the use of instructional technology and authentic examples as a way to enhance engineering education. This study was meaningful in that it captured the nature of students' satisfaction with engineering teaching using the survey instrument as well as the open-ended focus group discussion. Still, the study results cannot be generalized since the study was conducted with only a small number of students. Also, since the survey and interview questions were concerned with engineering education in particular, the results cannot be generalized to all STEM subjects.

For this reason, we designed a qualitative research study to explore open-ended students' perspectives on course instruction in college STEM fields. In particular, we examined the data from course rating websites where students can freely leave personal thoughts about the course and instructor at any time in addition to traditional course evaluations that are often administered at the end of semester by a university. In the course rating websites, students can rate their course or course instructor in terms of helpfulness, easiness, and clarity on a 5-point Likert scale. In addition to Likert scale ratings, students can add rationales about their ratings in the commentary section. For example, students describe the reasons why they rated the instructor high or low and in what aspects instructor was helpful or not. They participate in this online community to share their learning experiences in class. In fact, many college students use the course rating websites to decide the courses they would like to take in the beginning of the semester.

While the growing number of college students use and rely on course rating websites, few studies have been conducted to examine the impact of the course rating websites (Silva et al., 2008). Some researchers are skeptical about considering students' opinions in course rating websites since their postings could be emotionally biased depending upon students' final grades. Yet studies reported that students tend to post more positive comments than negative ones, including compliments and concerns about instructors' competence as well as comments about their learning progress (Kindred & Mohammed, 2005; Silva et al., 2008; Strand, 2006). Also, given a significant correlation between traditional course evaluation and course rating websites (Brown, Baillie, & Fraser, 2009; Otto, Sanford, & Ross, 2008; Timmerman, 2008), students' perspectives reflected in the course rating websites are worth exploring.

Methods

As a way to explore students' perspectives on college STEM courses, we chose to gather document data from the commentary section of course rating websites. There are several reasons we focused on this particular type of data. First, the commentary section allows students to reflect their thoughts in open-ended conditions and to supply answers in their own words, and such qualitative data can provide a rich body of data that cover various aspects of college courses. Also, researchers can gather student feedback that have accumulated for many years in a shorter period of time rather than collecting other types of qualitative data such as interview or observation data. This allows researchers to collect data in a cost-effective way and to derive general patterns and common attributes across different STEM courses. In addition, since documents are non-reactive to researcher's subjectivity, researchers are able to collect data that are objective and unaffected by the research process (Bowen, 2009). For these reasons, this study used document analysis to obtain students' perception about college courses. Document analysis involves a deductive process that helps researchers explore the reality and uncover findings that the literature may have missed or have overlooked (Prior, 2003).

Data Collection

We collected student comments on college STEM courses and instructors from two course-rating websites: RateMyProfessor.com and Koofers.com. RateMyProfessor.com is the largest, most well-known professor-rating website in the US by far. In May 2003, 2.7 million ratings of 478,000 faculty members had occurred, and by August 2006 the numbers had risen to over 5.7 million ratings of about 770,000 professors in nearly 6,000 schools (Silva et al., 2008). Currently, RateMyProfessors.com contains over 14 million student comments of 1.7 million professors (RatemyProfessor.com, 2014). This website provides students' overall ratings and comments about a variety of courses offered at different colleges and universities in the United States. It allows individual students to rate a professor in terms of the four aspects: easiness, helpfulness, clarity, and rater interest.

Koofers.com is a social-learning website that provides free, open access to course-related materials. This website allows students not only to rate and evaluate their instructors, but also to share their class materials such as class notes and study guides. It also presents the grade point average that students have received in the class. Koofers adheres to honor codes and academic integrity policies at each university by regularly communicating with university personnel and

faculty and forbidding the distribution of prohibited materials such as exams, papers, and tests that have not been permanently returned. According to Koofers.com, in October 2012, 735,000 college students were registered to the website, and over 530,000 professor ratings were available (Koofers.com). Although there are several other websites where college students can rate their instructors (e.g., KnowYourProfessor.com, MyEdu.com, and RateMyTeachers.com), we chose these two based on their growing popularity among college students.

We focused on the courses offered in one institution located in the southeastern United States. This strategy ensured control of any influence on student satisfaction that may exist at the institutional level. We obtained student comments from the courses that met the following criteria: (a) courses offered in the STEM area: (b) courses that involved more than 50 students in a classroom (large lecture-format courses), (c) courses that are offered every year in order to obtain sufficient data for analysis, and (d) courses that were rated with four stars or above and courses that were rated with two stars or below for the purpose of comparing high-rated courses and low-rated courses. We identified the courses that met criteria two and three based on the registration information provided by the institution to which researchers had access. There were four courses with high ratings (i.e., four stars or above) and four courses with low ratings (i.e., two stars or below) that met the four criteria above. The high-rated courses included ones in physics, physiology, chemistry, and biology; the low-rated courses were ones in animal science, microbiology, entomology, and biology. Some of the courses were part of the core curriculum for the university, and others were offered as major/elective courses. A different instructor taught each of the eight courses. We collected student comments that were made for these courses from January 2005 to November 2011 (the first course ratings were made in 2003). After the data selection process, we obtained a total of 343 student comments.

Data Analysis

The data were analyzed through thematic analysis. Thematic analysis is a form of a pattern recognition technique by searching through the data for emerging themes (Fereday & Muir-Cochrane, 2006). Two researchers independently reviewed students' comments of the high-rated and low-rated courses line by line and identified recurring patterns in the data. The patterns identified by each researcher were compared to ensure validity of the codes. With the codes on which there was no consensus, the two researchers shared their perspectives and concerns and reached common codes. Through multiple reviews and an iterative process, categories and codes were refined and grouped into themes.

Results

Four themes emerged from the data: (a) teaching styles, methods, or strategies; (b) teacher knowledge and preparation; (c) teacher attitude; and (d) practical workload and expectations. Themes and the examples are summarized in Table 1. These themes represent factors pertinent to student satisfaction with college STEM courses.

Teaching Styles, Methods, or Strategies

Students in the high-rated courses frequently reported that their instructors were able to explain materials in a manner they could easily understand. Some of them commented that use of good examples, analogies or stories was particularly helpful. They were also partial to the fact that the instructors applied the course materials to real life situations so that students were able to maintain their interest in the class. Moreover, the instructors of the high-rated courses tend to incorporate hands-on demonstrations or interactive activities rather than using lectures alone. For example, students in the poultry science course reported that the instructor brought in birds with which students could interact. In contrast, students in the low-rated courses often commented that lectures were not coherent or organized. They commented that many instructors read straight from their PowerPoints slides and did not elaborate on them, as these student comments illustrate: "All he does is read the PowerPoints and go off on tangents that DO NOT MATTER," and, "He just talks, so you have to be able to differentiate what is just jabber and what is important to know." They seemed annoyed by the instructors' off-topic lectures and inappropriate use of examples or analogies. In terms of teaching strategies, a large number of students also mentioned an instructor's ability to adjust the difficulty of the instruction based upon students' understanding. For example, when the instructor found that students were having hard time understanding a concept, the high-rated course instructors created extra examples or activities which were not stated in the syllabus. One student stated, "She explains something 10 times if the class needs her to." In contrast, the low-rated course instructors tended to adhere to a limited number of examples even when students had difficulties on understanding the concepts.

Teacher Knowledge and Preparation

Students in the high-rated courses often commented that their professors were knowledgeable

Table 1
Four Themes on College STEM Course Instruction from Students' Perspectives

Themes	Description	Example comments
Teaching styles, methods, or strategies	How teacher delivers contents in a manner students could easily understand	High-rated courses: • She makes the class interesting for non-interested people, relating it to everyday life and real situations so you can actually apply what you've learned. • Dr. X gives in class assignments that are helpful for understanding the concepts presented in lecture. • Amazing teacher. She really knows the subject and does a good job of clearly communicating it to the class. Low-rated courses: • Did not have good lectures and did not convey the material in a clear and explicit manor. • Worst class I've ever taken . . . his teaching style is to drop a bunch of slides with various lists that you have to memorize.
Teacher knowledge and preparation	Teachers' adequate knowledge and preparation to support students' knowledge gains and thinking skills	High-rated courses: • Great Professor who knows what's he's talking about. • She was always super prepared to teach. Low-rated courses: • She makes mistakes on simple concepts displayed on the PowerPoint slide and does not even correct herself. She teaches concepts incorrectly, occasionally, and does not emphasize the most important material.
Teacher attitude	Teachers' willingness to support students' learning and interact with students	High-rated courses: • AWESOME! Best teacher I've ever had. More than willing to help you out. • Easy to talk to and actually wants students to understand and do well. Low-rated courses: • It was as if he wanted to mock our class for not being chemist. He absolutely ignores students with questions. • He would get frustrated when people would ask questions and he often never answered them.
Practical workload and expectations	The alignment between the course objectives, lecture styles, and the assessment	High-rated courses: • Tests are fairly easy if you pay attention and go over the study guide that is given. • Tests are directly from the readings and notes, no trick questions. • A good amount of textbook reading, and attendance is necessary. Low-rated courses: • His tests have little to do with anything you read or heard. • His lectures were useless and his homework assignments were impossible to master and actually learn from.

and well-prepared to support students. For instance, students explicitly mentioned "knows the subject," "knowledgeable about subject," "displays an enormous amount of knowledge," and "great professor who knows what he's talking about." In low-rated courses, conversely, students criticized the instructor with comments like "notes were straight from Wikipedia and the book," and, "[My professor] does not seem to know more than the students about general anatomy and physiology." The usefulness of supplementary materials is addressed often in the high-rated courses as an indicator of the instructor's preparation. For instance, one student reported that his/her instructor in an introductory biology course provided PowerPoint slides before class so that students could preview the lecture. Also, clicker questions the instructor asked to students in the class were offered to students after the class so that students could review what they had learned in the class.

Furthermore, students were satisfied when the instructor not only focused on knowledge transfer, but also on improving students' thinking skills by "providing hypothetical examples and case examples" so that students can apply the knowledge to their everyday lives. Comments about supplementary materials were also found in low-rated course comments; however, students doubted the usefulness of the materials. More specifically, although instructors in low-rated courses provided supplementary materials in a timely manner, students used their own notes to follow the lecture rather than using the materials, as the supplementary materials were disconnected from the instructors' lecture. In addition, students who were highly satisfied with the course mentioned the usefulness of the review session that the instructor provided. A number of students in high-rated courses mentioned their satisfaction with review sheets or practice tests before tests, while students in low-rated courses complained about not having review sessions or having useless review chances, such as practice tests without correct answers.

Teacher Attitude toward Teaching, Subject, and Students

Students seemed to like instructors who were willing to help students. Students in highly rated courses frequently commented about the instructors' willingness to help students' learning. For example, comments in the high-rated courses include, "She really wants everyone to do well," "She is always willing to help you with any question," "Never patronizing no matter how dumb your questions may be," and, "She always answers questions thoroughly in class and really makes sure everyone understands the material before moving on." Also, students tended to rate a course highly if the instructors were passionate about teaching or the subject: "Loves what he teaches. He is enthusiastic," and, "She loves what she does and makes you interested in it too." On the other hand, students in the low-rated courses reported that these instructors did not care about teaching or students: "If you ask questions, he looks personally offended"; "If you go to her for help she has an attitude and makes you feel like crap"; and "Don't try to disagree and or correct one of his points. He blatantly refuses to listen to students." The comments indicated that the instructors often neglected to respond to students' questions or treated them as unintelligent questions. Some students felt only inferior in front of those instructors. One comment on a low-rated course even said, "She seems like she wants all of her students to fail."

Practical Workload and Expectations

Some students in the low-rated courses complained that the level of materials was more advanced than the course objectives. For example, one of the comments was, "He tried to fit all of his knowledge into a 1000-level class which just isn't feasible." Moreover, students expressed frustration when they were tested on materials that were not covered in class. On the other hand, students rated a course highly if the instructors' course expectations matched their own. For instance, one student commented, "He understands that most of the people in this class are not going to be entomologists. . . . He just wants you to be able to know more about bugs in general." Both students in high- and low-rated courses addressed the coherence of the assessment and teaching. Highly satisfied students frequently mentioned that their tests matched their expectations and were similar to what they had been taught by the instructor. Students of the high-rated courses mentioned, "The tests are . . . very straightforward from the lecture and the book pages she assigns" and "Tests are very easy and predictable if you pay attention to her way of thinking." Students were concerned not only about the aspect of test difficulty, but also about the validity of the evaluation—a discrepancy between the instructional style and what was tested. Students in the low-rated courses continuously commented about the discord between what and how they learned and the assessment. For example, while the instructor in an introductory biology class for non-majors taught often by posing various cases and examples rather than providing facts in the textbook, students reported that the test only asked the specific information in the textbook. Student comments that indicate the discrepancy between the class instruction and the evaluation are as follows: "PowerPoints, pre class assessments, and clicker questions are NOTHING like the test questions"; "The tests did not follow the notes . . . and she doesn't really explain HOW to relate the material to everyday life, but that is what you are tested over"; "His tests have little to do with anything you read or heard"; and "She makes it seem that the mini tests and finals are all based on her PowerPoints, but that as simply not the case, I would suggest reading the book before all tests."

In summary, college students seem to be satisfied with courses in which materials are presented with clear instruction. Also, they liked instructors who were open to questions and willing to help students. If instructors were enthusiastic about a subject, students were more likely to be interested in it as well. Finally, students became frustrated by the instructors' unreasonable expectations about class workloads.

Discussion

This study explored the elements of instruction that influenced student satisfaction in college STEM courses. We gathered student comments from two course-rating websites to understand these teaching

characteristics from students' perspectives. In particular, we compared student comments on high-rated courses with those on low-rated courses. In the following, we briefly review the four themes of teaching characteristics germane to college STEM course satisfaction and discuss how they are related to, and distinct from, previous research. We conclude with limitations and implications of the study.

The first theme was related to the quality of instructional techniques. Students in the low-rated courses frequently reported confusion in the lessons and perceived limited support from the instructor. On the other hand, students in the high-rated courses mentioned that the lecture was clear and well-elaborated with appropriate examples and applications. Also, the instructors of the high-rated courses were flexible and responsive to students' needs in their teaching. In the literature, using practical examples and responding to student feedback have been long recognized as effective teaching strategies to enhance student learning (Bransford, Brown, & Cocking, 2000; Tennyson & Cocchiarella, 1986).

The second element that affected student satisfaction was teacher knowledge and preparation. While students in the high-rated courses were content with the ample resources provided by their instructors, those in the low-rated courses expressed frustration at their instructors' lack of knowledge.

The third theme was teacher attitude. Instructors in the high-rated courses were perceived to be passionate about teaching and student learning; on the other hand, those in the low-rated courses were viewed as having only a minimal interest in teaching. This finding is consistent with the previous research that found teacher attitude to be one of the predictors of student learning. Students demonstrated greater performance when they perceived their teachers as enthusiastic and caring (Osterman, 2000; Patrick, Hisley, & Kempler, 2000).

The last component of instruction that influenced student course satisfaction was practical workload and expectations. Student frequently reported dissatisfaction when they perceived a gap between what they had learned and what they were assessed on. Student comments also implied that instructors of low-rated courses failed to establish the agreed course requirements that satisfy students' needs. Students in the low-rated courses frequently reported that the class was above the level they had expected. It is well known that alignment between learning objectives, learning activities and assessment is critical for promoting learning (Anderson & Krathwohl, 2001; Bransford et al., 2000). This last theme suggests the added importance of such alignment in that it also affects student course satisfaction.

As you may have noticed, all four themes found in the study are consistent with what we have generally regarded as attributes of good quality teaching. In fact, each theme corresponds to the five characteristics of effective teaching that NRC (2003) summarized. For example, the first theme is compatible with the second characteristic of effective college STEM teaching: skill, experience and creativity with a range of appropriate pedagogies and technologies. The second theme can be linked to the first characteristic (knowledge of subject matter); the theme of teacher attitudes is pertinent to the teaching characteristics of professional interactions with students and involvement with one's profession. The fourth theme of practical workload and expectations is related to appropriate assessment practices. These findings suggest that college students' satisfaction with a STEM course is largely dependent on the effectiveness of the teaching. In other words, students are satisfied with their STEM courses in which they have received quality education. While most existing research has emphasized these characteristics of effective teaching to increase students' learning, this study found that what we regard as effective teaching is also a key to student course satisfaction, which relates to student retention.

Implications of the Study

Because of the need to increase the number and quality of STEM students, teachers, and practitioners, the National Science Foundation (NSF) has increased its promotion of STEM innovators (Kuenzi, 2008). The NSF, for example, has invested $7 billion annually in America's colleges and universities to promote discoveries and provide strategies. American universities are expected to play a vital role in educating and training undergraduate and graduate level scientists and engineers. Still, despite significant financial and human resources, the needs remain (NRC, 2012). This study suggests that the effectiveness of teaching is the critical factor that has a great impact on student satisfaction and retention in STEM courses. The rate of students dropping out from STEM majors might increase, not because the students are incapable or dislike STEM, but because they do not have a chance to receive effective instruction.

One thing that instructors in STEM fields can do to develop and improve their instructional strategies is to constantly communicate with students and seek out feedback from them throughout the semester. Generally, most colleges ask students to respond to formal course evaluations at the end of the semester. Because this is the only time when instructors receive feedback from students, instructors can hardly address students' needs or preferences during the semester. Beyond the final course evaluations, offering a mid-course evaluation to students will be a decent way to communicate with students during the semester so that

instructors can have chance to recognize students' needs before the semester ends. The mid-course evaluation may not necessarily need to be provided university-wide; rather, it could be offered by individual instructors. Instructors often believe that students tend to evaluate the course based on easiness of the course or students' biased perception about the course, especially when students use course-rating websites. The students' responses in the course-rating websites have sometimes been depreciated since some comments focused on professor's characteristics and personality with negative and emotional remarks and nonspecific statements. However, as Strand (2006) addressed, students' comments were not nearly as vitriolic, bombastic, or extreme as some would have us believe.

Instead of confirming negative expectation that students' responses in the course rating websites are emotionally biased and highly depend on the final grade they earned, this study yielded results that support the value of course-rating websites. This study found that students express their opinions about the quality of the instruction in the course-rating websites, and those opinions are aligned with characteristics of effective teaching reported in the literature. In this manner, this study sheds new light on the validity of course-rating websites that instructors may refer to as a way to improve their instruction. Without instructors' acknowledgement of students' perceptions, needs, and preferences and instructors' efforts to reflect students' perspectives in their everyday classroom instruction, the findings would remain as just another theoretical approach. Thus, we suggest student evaluation in the course-rating websites is worthwhile for instructors to take into consideration.

Limitations of the Study and Directions for Future Research

Our findings in the present study are subject to several limitations. To reduce unexpected variables that would be generated by including different types of universities, the current study focused on incidents at one university. Given the small sample size, caution must be applied, as the findings might not be transferable to all college level educational institutions. Further research should replicate the study with different, but similar levels of, universities in order to increase the generalizability of the findings. In addition, the current study was unable to separate courses that are taken by majors or non-majors of STEM subjects. Compared to STEM majors, non-STEM major students sometimes do not have adequate backgrounds from their high school experiences or their learning styles do not readily adapt to the environment of larger, less personal classrooms and teaching laboratories (Linn & Eylon, 2006). Depending on students' majors, different types and levels of instruction as well as teaching strategies should be offered to the class. Future research needs to explore how STEM and non-STEM students' needs are different in order to provide appropriate learning environments that will reflect those student groups' needs. Also, students' needs may vary depending on each of the STEM fields. While the purpose of the current study was to explore the general patterns across different STEM fields, future studies are necessary to investigate domain-specific student perspectives and needs. Another limitation relates to the nature of course rating websites. Students can evaluate courses at any time, even after they graduate from college. Thus, it is possible that a student who posted in mid-semester may have a different perspective than a student who posted after the semester ended. Finally, analysis of documents enables the current study to understand students' general perceptions about teaching from one data source in the STEM area. In order to address domain-specific learning needs, future research is recommended to use multiple data sources to define prominent learning problems students may encounter. Not only analyzing students' comments, but also triangulating documents with focus group interviews or anonymous surveys, will help to address students' needs and will strengthen the understanding of students' perceptions.

References

American Association for Higher Education. (1996). *What research says about improving undergraduate education*. Washington, DC: Author.

Anderson, L., & Krathwohl, D. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York, NY: Addison Wesley Longman.

Astin, A. W., Parrott, S. A., Korn, W. S., & Sax, L. J. (1997). *The American freshman: Thirty year trends.* Los Angeles, CA: Higher Education Research Institute, University of California, Los Angeles.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27-40. doi:10.3316/QRJ0902027

Bransford, J., Brown, A., & Cocking, R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Brown, M. J., Baillie, M., & Fraser, S. (2009). Rating RateMyProfessors.com: A comparison of online and official student evaluations of teaching. *College Teaching*, *57*(2), 89-92. doi:10.3200/CTCH.57.2.89-92

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. Lawrenceville, NJ: Princeton University Press.

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *CBE Life Sciences Education*, *6*(1), 9-20. doi:10.1187/cbe.06-12-0205

Calvo, R. A., Markauskaite, L., & Trigwell, K. (2010). Factors affecting students' experiences and satisfaction about teaching quality in engineering. *Australasian Journal of Engineering Education*, *16*(2), 139-148.

Chen, X., & Weko, T. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education*. Washington, DC: U.S. Department of Education.

Collis, B., & Moonen, J. (2002). Flexible learning in a digital world. *Open learning*, *17*(3), 217-230. doi:10.1080/0268051022000048228

Dey, E. L. (1991). *The American freshman: Twenty-five year trends, 1966-1990*. Los Angeles, CA: Higher Education Research Institute, University of California, Los Angeles.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods, 5*(1), 80-92.

Glassick, C. E., Huber, M. T., Maeroff, G. I., & Boyer, E. L. (1997). *Scholarship assessed: Evaluation of the professoriate*. San Francisco, CA: Jossey-Bass.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching*, *46*(2), 127-146. doi:10.1002/tea.20267

Gormally, C., Brickman, P., & Lutz, M. (2012). Developing a test of scientific literacy skills (TOSLS): Measuring undergraduates' evaluation of scientific information and arguments. *CBE-Life Sciences Education*, *11*(4), 364-377. doi:10.1187/cbe.12-03-0026

Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education, 9*(1), 25-45.

Higher Education Research Institute. (2010). *Degrees of success: Bachelor's degree completion rates among initial STEM majors*. Los Angeles, CA: Higher Education Research Institute, University of California, Los Angeles. Retrieved from http://heri.ucla.edu/nih/downloads/2010%20-%20Hurtado,%20Eagan,%20Chang%20-%20Degrees%20of%20Success.pdf

Honan, W. H. (2002, August 14). The college lecture, long derided, may be fading. *The New York Times*. Retrieved from http://www.nytimes.com/2002/08/14/education/14LES.html

Hutchings, P. (1996). Building a new culture of teaching and learning. *About Campus*, *1*(5), 4-8.

Kennedy, S. H. (*1997*). Is there a genetic basis to endometriosis? *Seminars in Reproductive Medicine, 15*(3), 309-317. doi:10.1055/s-2008-1068761

Kindred, J., & Mohammed, S. N. (2005). "He will crush you like an academic ninja!": Exploring teacher ratings on RateMyProfessors.com. *Journal of Computer-Mediated Communication, 10*(3). doi:10.1111/j.1083-6101.2005.tb00257.x

King, A. (1994). Inquiry as a tool in critical thinking. In D. F. Halpern (Ed.), *Changing college classrooms: New teaching and learning strategies for an increasingly complex world* (pp. 13-38). San Francisco, CA: Jossey-Bass.

King, P. M., & Kitchener, K. S. (2004). Judgment model: Twenty years of research on epistemic cognition. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and* knowing (pp. 37-61). Mahwah, NJ: Lawrence Erlbaum.

Kuenzi, J. (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action* (Congressional Research Service Report RL33434). Retrieved from the Federation of American Scientists website: http://www.fas.org/sgp/crs/misc/RL33434.pdf

Kuh, G. D. (2001). *The national survey of student engagement: Conceptual framework and overview of psychometric properties.* Bloomington, IN: Indiana University Center for Postsecondary Research.

Linn, M. C., & Eylon, B.S. (2006). Science education: Integrating views of learning and instruction. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 511-543). Mahwah, NJ: Lawrence Erlbaum.

Lizzio, A., Wilson, K., & Simons, R. (2002). University students' perceptions of the learning environment and academic outcomes: Implications for theory and practice. *Studies in Higher Education*, *27*(1), 27-52. doi:10.1080/03075070120099359

Loverude, M. E., Kautz, C. H., & Heron, P. R. (2002). Student understanding of the first law of thermodynamics: Relating work to the adiabatic compression of an ideal gas. *American Journal of Physics*, *70*(2), 137-148. doi:10.1119/1.1417532

MacArthur, J. R., & Jones, L. L. (2008). A review of literature reports of clickers applicable to college chemistry classrooms. *Chemistry Education*

Research and Practice, 9(3), 187-195. doi:10.1039/b812407h

Marchese, T. J. (2002). The new conversations about learning: Insights from neuroscience and anthropology, cognitive science and work-place studies. In *Assessing Impact: Evidence and Action* (p. 79-95). Washington, DC: American Association for Higher Education.

Mestre, J. P. (1994). Cognitive aspects of learning and teaching science. In S. J. Fitzsimmons & L. C. Kerpelman (Eds.), *Teacher enhancement for elementary and secondary science and mathematics: Status, issues and problems* (pp. 3-53). Arlington, VA: National Science Foundation.

Minstrell, J. A. (1989). Teaching science for understanding. In L. Resnick & L. Klopfer (Eds.), *Toward the thinking curriculum: Current cognitive research*. (pp. 129-149). Alexandria, VA: Association for Supervision and Curriculum Development.

National Institute for Science Education. (1999). *Learning through technology*. Madison, WI: University of Wisconsin-Madison. Retrieved from http://www.wcer.wisc.edu/nise/cl1/ilt/

National Research Council (NRC). (1999). *Transforming undergraduate education in science, mathematics, engineering, and technology*. Washington, DC: National Academy Press.

National Research Council (NRC). (2003). *Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics (STEM)*. Washington, DC: National Academic Press.

National Research Council (NRC). (2012). *Research universities and the future of America: Ten breakthrough actions vital to our nation's prosperity and security*. Washington, DC: National Academies Press.

National Science Board. (2007). *A national action plan for addressing the critical needs of the US science, technology, engineering, and mathematics (STEM) education system*. Arlington, VA: National Science Foundation.

Osterman, K. F. (2000). Students' need for belonging in the school community. *Review of Educational Research, 70*(3), 323-367. doi:10.3102/00346543070003323

Otto, J., Sanford D. A., Jr., & Ross, D. N. (2008). Does RateMyProfessor.com really rate my professor? *Assessment & Evaluation in Higher Education*, *33*(4), 355-368. doi:10.1080/02602930701293405

Patrick, B. C., Hisley, J., & Kempler, T. (2000). "What's everybody so excited about?": The effects of teacher enthusiasm on student intrinsic motivation and vitality. *Journal of Experimental Education, 68*(3), 217-236. doi:10.1080/00220970009600093

Pomales-García, C., & Liu, Y. (2007). Excellence in engineering education: Views of undergraduate engineering students. *Journal of Engineering Education*, *96*(3), 253-262. doi:10.1002/j.2168-9830.2007.tb00934.x

Prior, L. (2003). *Using documents in social research*. Thousand Oaks, CA: Sage.

Ramsden, P. (1991). A performance indicator of teaching quality in higher education: The course experience questionnaire. *Studies in Higher Education*, *16*(2), 129-150. doi:10.1080/03075079112331382944

RateMyProfessor.com. (2014). *About RateMyProfessors.com*. Retrieved from http://www.ratemyprofessors.com/About.jsp

Schulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Seymour, E. (2002). Tracking the processes of change in U.S. undergraduate education in science, mathematics, engineering, and technology (STEM). *Science Education, 86*, 79-105.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Silva, K. M., Silva, F. J., Quinn, M. A., Draper, J. N., Cover, K. R., & Munoff, A. A. (2008). Rate my professor: Online evaluations of psychology instructors. *Teaching of Psychology, 35*(2), 71-80. doi:10.1080/00986280801978434

Smith, K. A., Douglas, T. C., & Cox, M. F. (2009). Supportive teaching and learning strategies in STEM education. In R. Baldwin (Ed.), *New directions for teaching and learning: Improving the climate for undergraduate teaching in STEM fields* (Vol. 117, pp. 19-32). San Francisco, CA: Jossey-Bass.

Stephans, J., Dyche, S., & Beiswenger, R. (1988). The effect of two instructional models in bringing about a conceptual change in the understanding of science concepts by prospective elementary teachers. *Science Education*, *72*(2), 185-195. doi:10.1002/sce.3730720207

Strand, E. (2006, July 28). Let's sue. *Chronicle of Higher Education*. Retrieved from http://chronicle.com/jobs/news/2006/07/200607280 1c /careers.html

Surridge, P. (2008). *The national student survey 2005-2007: Findings and trends*. Retrieved from http://www.hefce.ac.uk/media/hefce/content/pubs/indirreports/2008/rd1208/rd12_08.pdf

Tennyson, R., & Cocchiarella, M. (1986). An empirically based instructional design theory for teaching concepts. *Review of Educational Research, 56*(1), 40-71. doi:10.3102/00346543056001040

Timmerman, T. (2008). On the validity of RateMyProfessor.com. *Journal of Education for Business*, *84*(1), 55-61. doi:10.3200/JOEB.84.1.55-61

Terenzini, P. T., Springer, L., Yaeger, P. M., Pascarella, E. T., & Nora, A. (1996). First-generation college

students: Characteristics, experiences, and cognitive development. *Research in Higher Education, 37*(1), 1-22.

Yang, Y. F., & Tsai, C. C. (2010). Conceptions of and approaches to learning through online peer assessment. *Learning and Instruction*, *20*(1), 72-83. doi:10.1016/j.learninstruc.2009.01.003

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