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Perceptions and Influences Behind Teaching Practices: Do Teachers Teach as They Were Taught?

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ABSTRACT

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Schools face the problem of recruiting and retaining students in Science, Technology, Engineering, and Mathematics (STEM) degrees. One reason that students leave STEM fields is because their introductory classes are too hard or not engaging. These introductory classes are typically taught using a lecture-heavy, instructor-centered approach, contrary to current evidence based pedagogy. Many who call for teacher reform put the blame on the way teachers are educated, which is often not student-centered, citing that because 'teachers teach the way they were taught,' current education is also not student-centered. The idea that 'teachers teach the way they were taught' is commonly used to promote an agenda for improved teaching training and accepted as fact in the scientific literature. However, little empirical data has been collected to support this conclusion. We aimed first to determine empirically if teachers teach the way they were taught, and second to determine the influences behind teaching practices. We observed, surveyed, and interviewed a sample of 44 instructors at seven colleges and universities throughout the state of Utah who taught select STEM introductory courses. Instruments used included observational, survey, and interview protocols developed specifically for this study during preliminary trials, and inspired by the Reformed Teaching Observation Protocol (RTOP). A paired t-test was used to compare the professors' teaching practices with their own educational experiences. Interview responses were then grouped into common categories and used to determine the influences behind teaching practices. We discovered that there is a significant difference between how teachers teach and how they were taught during their own educational experience. This finding does not support our hypothesis that teachers teach the way they were taught. Qualitative data from interviews introduces a new hypothesis that teachers teach the way they themselves *preferred* to be taught, or the way they think students learn *best*, demonstrating that teachers are taking a much more metacognitive approach to teaching than is suggested by that famous quote, 'teachers teach the way they were taught.' Our results suggest that reform classes and workshops develop a more metacognitive approach to exposing future teachers to current, evidence based pedagogy, allowing teachers to reflect on their own learning and experience for themselves the benefits of student-centered learning. These future teachers will then apply what they learn if they are convinced it is a better way to teach students. They will teach the way they were taught because they experienced a positive experience when leaning.

Keywords: student-centered learning, reformed teaching, teaching practices, undergraduate education, STEM retention

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INTRODUCTION

A well-documented problem in science, technology, engineering, and mathematics (STEM) fields is the retention of students in these college majors (Astin, Astin, & Angeles, 1992; Holmegaard, Madsen, & Ulriksen, 2014; Koenig, Schen, Edwards, & Bao, 2012; Perez, Cromley, & Kaplan, 2014; Wilson et al., 2012). This is happening despite the National Science Foundation's attempts to increase students' participation (Holmegaard et al., 2014). Students are leaving STEM majors at an alarming rate. Some studies show more than 40% of STEM students switching to a non-STEM major before graduation (Koenig et al., 2012; Perez et al., 2014; Seymour & Hewitt, 1997). However, even more interesting is the fact that most students switch out of a STEM field in their first or second year at school, saying that their freshman science classes were the most influential factor in deciding whether to stay or go (Watkins & Mauzr, 2013). Why are students leaving STEM fields in their first couple of years at college? Several reasons could explain this phenomenon. Koenig (2012) reported that students feel their high school experiences did not prepare them for college classes. Incoming freshman are not prepared in reasoning ability and content area and hence do not do well in introductory STEM classes (Koenig et al., 2012). Some other reasons include a decreased confidence from bad grades in introductory classes, difficulty with the material, reduced interest in science, a too-demanding curriculum, and poor instruction (Koenig et al., 2012; Perez et al., 2014; Watkins & Mazure, 2013).

One major reason mentioned above that is influencing students' decision to stay or go seems to be the introductory classes themselves (Koenig et al., 2012). The Advisory Committee to the NSF Directorate for Education and Human Resources listed introductory STEM classes as being the largest obstacle to students staying enrolled in a STEM field; the courses were seen as too competitive, too difficult, and were taught in large, impersonal lecture format (Koenig et al., 2012).

In the past, most college undergraduate classes have been taught using a traditional approach, which includes heavy lecture from the instructor and the expectation that students will listen and takes notes (Smart, Witt, & Scott, 2012). This approach to teaching has been found to be less effective (Smart et al., 2012). A new movement toward a student centered approach (e.g., active learning, inquiry-learning, problem-based learning), has been found to be more effective in all areas tested (Çubukcu, 2012; Freeman et al., 2014; Heiss, Obourn, & Hoffman, 1950; Howard & Miskowski, 2005; Jafari, 2014; Jensen & Lawson, 2011; Keengwe, Onchwari, & Onchwari, 2009; Lawson, 2002; Miller, McNear, & Metz, 2014; Minner, Levy, & Century, 2010; Renner, Stafford, Coffia, Kellogg, & Weber, 1973; Rissing & Cogan, 2009; Sesen & Tarhan, 2011; Smart et al., 2012; Spiro & Knisely, 2008; Van Horn, Hyde, Tesh, & Kautz, 2014). Student-centered teaching has been thoroughly researched and the benefits well documented, including a more positive attitude towards science, a better understanding of science content, and improved reasoning skills (Çubukcu, 2012; Freeeman et al., 2014; Heiss et al., 1950; Howard & Miskowski, 2005; Jafari, 2014; Jensen & Lawson, 2011; Keengwe et al., 2009; Miller et al., 2014; Minner et al., 2010; Renner et al., 1973; Rissing & Cogan, 2009; Sesen & Tarhan, 2011; Smart et al., 2012; Spiro & Knisely, 2008; Van Horn et al., 2014). However, even though there is strong support for the benefits of this approach to teaching, many undergraduate classes are still not taught this way (Momsen, Long, Wyse, & Ebert-May, 2010).

One reason that undergraduate classes are taught using a more teacher-centered approach could be because ‘teachers teach the way they have been taught’ (Cheek & Castle, 1981; Chicoine, 2004; Frank, 1990; Goodlad, 1982; Herrington, Sparrow, & Herrington, 1999;

Hornback, 2004; Karmas, 2011; Kennedy, 1991; Knowles, 1988; Meske, 1987; Pringle, 2006). This phrase is a commonly accepted idea in the education literature and is used in many peer reviewed articles to support other research (Hall, Fisher, Musanti, & Halquist, 2006; Johnson, Laughran, Tamppari, & Thomas, 1991; Marshall, 1991; McQuiggan, 2012; Short, 1993; Stitt-Gohdes, Crews, & McCannon, 1999; Stitt-Gohdes, 2001; Thompson, Orr, Thompson, & Park, 2002). It is also seen in opinion articles (Brown, 2003; Cheek & Castle, 1981; Chicoine, 2004; Frank, 1990; Goodlad, 1982; Herrington et al., 1999; Hornback, 2004; Karmas, 2011; Kennedy, 1991; Knowles, 1988; Meske, 1987; Pringle, 2006). It is part of the lore of teaching, and while its ultimate origin is unknown, it has been documented as early as 1975 (Lortie, 1975). Dan Lortie, a professor at the University of Chicago, coined the phrase 'the apprenticeship of observation' to describe how student teachers have already had much experience observing professional teachers by the time they go to college to become teachers themselves. Because of this vast experience, pre-service student teachers have many misconceptions about teaching, unlike students who study to become lawyers or doctors. As every student goes through his or her education, all they see is the teacher lecturing at the front of the room, being the center of attention. They do not observe any of the preparatory work that goes into each lesson. Hence, those students who go on to become pre-service student teachers are thought to simply imitate behavior that they have observed. This is the apprenticeship of observation (Lortie, 1975).

This observation was documented again in 1982 by John Goodlad. His was a call for reform and reconstruction on a school-wide scale. He thought that professional training came too late in pre-service student teachers' schooling, after years of being a student. The only way to solve this was to radically upgrade teacher education programs (Goodlad, 1982).This idea has also been described as 'teachers teach as they have been taught,' 'teachers teach the way they learn,' and 'teachers teach the way they learn best.' These are different ways to say one idea, that when a person teaches a lesson, they are more likely to teach using the methods they have experienced in their own education than using a different, even superior, method.

My hypothesis is that one reason instructors at colleges and universities teach using a more traditional approach is because they teach as they were taught. To evaluate this hypothesis, quantitative instruments were used as well as a large and varied population. I first determined empirically whether teachers teach the way they have been taught and second, explored why this pattern exists and what factors influence teaching practices. I predicted that if STEM instructors have been taught in their past education using a traditional approach, then they will in turn teach their classes using traditional teaching methods; however, if STEM instructors have been taught in their past education using a student-centered approach, then they will in turn teach their own classes using student centered teaching methods.

Literature Review

Why would teachers teach as they were taught? Carter (1997) ran a study where he examined teacher beliefs about mathematics as well as the students' beliefs about mathematics. He also looked at the teachers' beliefs about learning and teaching mathematics. He found that teachers will teach according to their beliefs about the subject material. Essentially, they practiced what they believed. This in turn affected their students' beliefs (Carter & Norwood, 1997; Frank, 1990). Brown (2003) theorized in an opinion article that teachers tend to use a more traditional approach because they have not been taught adult learning theory and do not understand it. However, if they do experience and learn it, then they are more likely to use a student centered approach in teaching. They are able to understand why it is better, because their understanding and beliefs about teaching are changed. However, Brown did not conduct research to confirm this idea. Other researchers surveyed teachers and educators about their preferred instructor styles and learning styles. They found that most teachers preferred to teach in a logical and organized way, with student working together; however, they also found that teachers thought the traditional approach was the easiest way to teach. It is what a professor was used to and what they feel most comfortable doing (Stitt-Gohdes et al., 1999).

In many peer reviewed articles, the statement that ‘teachers teach the way they have been taught’ has been used as part of the theoretical rationale for another hypothesis being studied (Hall et al., 2006; Johnson et al., 1991; Marshall, 1991; McQuiggan, 2012; Short, 1993; Stitt-Gohdes et al., 1999; Stitt-Gohdes, 2001; Thompson, Orr, Thompson, & Park, 2002). However, the term is used loosely, with all articles not citing any sources for the idea or citing another article that used it the same way but did not cite a source (Hall et al., 2006; Johnson et al., 1991; Marshall, 1991; McQuiggan, 2012; Short, 1993; Stitt-Gohdes et al., 1999; Stitt-Gohdes, 2001; Thompson et al., 2002). I examined 20 articles on education research over the past 30 years. 90% of these contained some form of the statement ‘teachers teach as they were taught’ without any citation of direct evidences. None of the articles directly tested the phrase, but simply used it to back up their own research in a different area. I will provide some examples. In an art education research article, the authors state that because teachers tend to teach as they were taught, it is important that pre-service teachers understand the content knowledge. They had found that prior knowledge has an influence on what pre-service teachers consider to be important about art, which affects how they teach their students (Short, 1993). In a study about online teaching, the idea that teachers teach as they were taught was used to support that a teacher’s teaching strategy comes from their own learning. However, when online teaching is used, there is a change in face-to-face teaching practices (McQuiggan, 2012). In a study conducted on technological use in the classroom, the idea that "teachers teach like they were taught" explains why technology is not often used in classrooms (pg. 25). The authors in this study decided that it is probably because technology is not being used in teacher preparation programs. However, they had no evidence to directly support that this was the causal factor (Hall et al., 2006). Johnson, Laughran, Tamppari, and Thomas (1991) determined that guidelines for adapting university science laboratories into middle school science activities were needed because teachers teach as they were taught.

In a study about teachers' learning styles, the authors state in the introduction that "teachers teach according to the way they learn," and so it was important to know a teacher's learning style in order to adjust to the learning styles of their students (Thompson et al., 2002, pg. 63). The authors used this phrase to justify conducting their research, which looked at learning styles of faculty and how they differed according to different characteristics. However, they did not directly test if teachers teach the way they learn, or even cite a source for it. Stitt-Gohdes, Crews, and McCannon also studied learning styles. In a study they conducted, they state that "literature has supported the belief that most teachers teach the way they learn best" as a supporting idea that student achievement will be highest when students' preferred leaning styles match their teacher's preferred learning style (Stitt-Gohdes et al., 1999, pg. 71). However, the only source cited which deals with this idea was a study by Marshall (1991) who survey teachers, asking them why they teach the way they do. The most common responses were that this is the way they were taught, or this is the way they learn best, or because it was the easiest way to cover the content (Marshall, 1991). I think a quantitative study would better test whether or not teachers teach the way they were taught. In later publication, Stitt-Gohdes (2001) conducted a study to find out if preferred leaning styles of students matched the preferred instruction styles of their teachers in secondary education. As an introduction to his idea, he stated that "research supports the concept that most teachers teach the way they learn;" however, there was no citation as far as what research supported the concept (Stitt-Gohdes, 2001, pg. 137).

In other peer reviewed articles, this idea is mentioned to encourage educational reform in schools. In a critique of traditional teacher education programs, Chicoine (2004) mentions that in order to keep teachers from "teach[ing] as they were taught by many of their own primary and secondary teachers," then the courses that these teachers take must exemplify active learning (pg. 245). Meske also talks about issues in teacher education reform and the need to stop the vicious circle which results from the tendency of teachers to "teach as they were taught, not as they were taught to teach" (Meske, 1987. pg. 25). Knowles determined that teachers who are just starting will teach as they were taught, which is why institutions that train teachers should be aware of the early formative experience of pre-service teachers, since early formative experience affects how new teachers think about teaching, a claim not backed by actual data (Knowles, 1988). Karmas discussed how most teachers follow a traditional method of teaching, and teach as they were taught in business classes. However, the active learning model is an alternative way of teaching; it can help students develop useful skills in business writing classes that will help them move from school to work and be successful (Karmas, 2011). Again, Kamas does not cite any studies supporting his ideas.

Pringle (2006) discussed in a recent article that there are many misconceptions students have about scientific concepts. However, teaching strategies have not been changed accordingly because "teachers tend to teach the way they were taught," again a claim not backed by evidence (pg. 292). In order to appropriately address these student misconceptions and change the way that teachers teach, Pringle claims that more needs to be done in teacher education to help teachers change their teaching strategies and break the cycle. In another opinion article, policy issues in teacher education in the United States were discussed, including teacher quality (Kennedy, 1991). The author found that teachers who entered the U.S. education system teach using poor teaching strategies, because they themselves were taught using those same poor strategies and "teachers are highly likely to teach in the way they themselves were taught" (pg. 662). Kennedy claimed that many beginning students rely on common sense and revert back to the teaching practices they themselves have experienced. However, no data was gathered here, which further supports the necessity for empirical evidence to be gathered.

Hornbach, in a response to another study conducted, argued that young teachers will have more success in teaching if they are taught how to teach, such as good classroom management skills and how to teach in different contexts. Otherwise, they will "teach how they were taught," which may or may not include proper teaching strategies (Hornbach, 2004, pg. 202-203). In 1981, Cheek & Castle observed that mathematics achievement was decreasing, and this was because teachers are still teaching as they were taught, despite reform (Cheek & Castle, 1981). In another study on teachers' beliefs and mathematics, Frank (1990) argued that mathematical content and methods courses for future teachers need to be redesigned so that teachers are taught the way they are expected to teach, because "teachers teach the way they have been taught," calling it a "widely accepted adage" (pg. 12). Herrington, Sparrow, and Herrington (1999) stated that there was a problem in mathematics curricula that stemmed from the fact that teachers teach the way they were taught and that reform is difficult to achieve. All of these claims to this effect are unsubstantiated, having no evidence to back them up.

In the above literature mentioned, the idea that teachers teach the way they have been taught has been used in research and opinion articles; however, the actual idea has only been tested a few times. In a study conducted by Adamson et al. (2003), researchers wanted to evaluate the effectiveness of the Arizona Collaborative for Excellence in the Preparation of Teachers (ACEPT) reform program. This program taught pre-service teachers how to teach using current, evidence based pedagogy. The classes were also taught using current, evidence based pedagogy. Pre-service teachers went through this program and then were observed and rated using the Reformed Teaching Observation Protocol (RTOP) instrument to see if they would now teach using current, evidence based pedagogy. The authors found that pre-service teachers did change their teaching methods to a more reformed approach, and concluded that "these results support the hypothesis that teachers teach as they have been taught" (Adamson et al., 2003). However, this study was conducted using pre-service teachers only, showing that if pre-service teachers went through the ACEPT reform program, they would in turn teach using reformed methods. The original hypothesis of Adamson's study was not to provide support for the idea that teachers teach the way they were taught, nor did the study directly evaluate instructors at colleges and universities.

A recent study published in 2013 by Oleson and Hora demonstrated an exploratory search into this phenomenon using faculty at research institutions. They interviewed and observed 53 STEM faculty across three institutions. Their analysis was qualitative and included an in-depth case-study of two faculty members. They found that faculty do mimic their past instructors as well as draw on their own knowledge and their prior experience as instructors, students, researchers, and non-academic roles (Oleson & Hora, 2013). This study is a large improvement from the previous one described and actually addresses past educational experiences and current teaching practices as well as looks at faculty members that do not have the formal education training that pre-service teachers are given. However, a quantitative analysis was not conducted between how teachers teach and their past experience. In my study, my goal is to provide a quantitative analysis.

Theoretical Rational

Two educational theories provide rationale for why teachers teach the way they were taught. Lev Vygotsky's theory can be used as a foundation for why teachers teach as they have been taught. His theory centered around child development, and that their cognitive development was formed by adults, society, and culture (Vygotsky, 1978). Under this theory, Vygotsky taught that scaffolding should be used to promote cognitive development, where more skilled mentors provide guidance to help less skilled students do something that is within their reach of mastery (Vygotsky, 1978). It is a type of guided teaching where the mentor helps the student, who in turn learns to mimic the mentor as the skill is taught. When the student has successfully mastered the skill, then the "scaffolding" or mentor is taken away, i.e., the student does not need the mentor's help anymore. Much like scaffolding in Vygotsky's theory, I suspect that the professor in the classroom could be providing guidance for students in the classroom as they learn the subject matter. In turn, the students may learn to mimic their professor, including the way they teach. The professor models the teaching method, and the student mimics it.

The idea of mimicry is also found in behaviorism, which is a theoretical perspective that explores stimuli in the environment and how that causes a change in behavior (Ormrod, 2000). People are prone to mimic what they have seen before, especially if they do not have experience in that area; hence, if professors need to teach a course, they are more likely to teach the way they themselves were taught the course. Another idea in behaviorism and social cognitive theory (proposed by Albert Bandura & Edward Thorndike, 1986) is positive reinforcement, that if a person does something and receives a reward, then they are more likely to do it again (Bandura, 2001). In education, those who end up in academia are those who succeeded in the traditional approach. Because they were able to get good grades, they were able to go on to graduate school and become professors. This acts as a positive reinforcement for a traditional approach to teaching, and so they are more likely to teach their own classes in this way; they will teach the way they have been taught, for this way leads to success.

Furthermore, most of the research cited above was looking at pre-service teacher preparation, where those teachers are given explicit training in education. In this study, we are looking at higher education professors and faculty members who do not receive explicit instruction. Therefore, I suspect that these teachers are much more likely to rely on these behaviorists approaches because they have not been taught how to teach.

MATERIALS AND METHODS

Participants

In order to accomplish my objectives, professors and faculty members in biology, chemistry, and physics were surveyed, interviewed, and observed at seven different universities and community colleges throughout Utah, including Brigham Young University (BYU), University of Utah (U of U), Utah Valley University (UVU), the Utah State University (USU) in Price, Utah, Weber State University (WSU), Snow College (SC), and Salt Lake Community College (SLCC). Professors and faculty members met the criteria for the study if they were teaching an introductory level class in biology, chemistry, or physics during the Fall 2013 semester. Instructors who satisfied this criteria but whose class also included a lab section were not used in the study in order to target teachers and classes that could not rely on a lab experience. Possible participants were identified through online school catalogs, contacted via email, and asked to participate in the study, following approved IRB guidelines. More than 80 instructors were asked to participate in the study; of those, 47 agreed to participate. However, 3 participants decided to withdraw before data collection began because of busy schedules. One participant was eliminated after their schedule changed and they were no longer teaching an introductory biology, chemistry, or physic class. No other participants were eliminated from the study after data collection began, for a total of 43 participants. Of these participants, 33 were males and 10 were females. There were 29 participants who taught biology, 8 participants who taught chemistry, and 6 participants who taught physics. From Brigham Young University, there were 19 participants, from the University of Utah, there were three participants, from Utah Valley University, there were eight participants, from Salt Lake Community College, there were seven participants, and there were two participants each from Weber State University, the Utah State University extension in Price, Utah, and Snow College. The idea was to allow as many volunteers as possible to participate in the study to get a large sample size and a diversity of participants.

Preliminary Trial

Preliminary trials were used to create the final questionnaire, interview protocol, and observation protocol used in this study. First, faculty members from the Life Sciences Department at Brigham Young University volunteered their personal time to be interviewed. The questions were designed to elicit any information that might have to do with how the instructor taught and why they taught that way, as well as any variables that might impact an instructor's teaching practices. Table 1 contains the questions asked in the interview.

Table 1. Preliminary interview questions.

Questions for Professors
1. Which class do you teach most often? Is this the class you are most comfortable teaching? If not, what class are you most comfortable teaching?
2. Describe how you teach a typical class period in this course (i.e., your most comfortable one) typical class (lecture, activities, in class quizzes, I-clickers, tests, demonstrations?)
3. Why do you teach that way? (Is it because you took an education class, someone let you use their curriculum, easiest, quickest and clearest coverage of information, students like it, someone showed you how to teach, etc.)
4. Which class are you least comfortable teaching? Why?
5. Do you teach this class differently than the last class we discussed? How so? Why?
6. Thinking back to your own education, describe to me how you were taught these two subjects.
7. About how long ago was that?
8. Can you remember your undergraduate and graduate education (what classes you took, how they were taught)? How was your education in general? Other than biology, the courses you had to take for your major/grad degree…were there any courses that stuck out to you and why? Do you think these courses influenced your teaching? If yes, how so?
9. Do you attend professional development meetings? Which ones?
10. What type of things have you implemented in your class from these meetings?
Demographic information
11. How many years have you been teaching?
12. What year did you graduate with your bachelors?
13. What year(s) did you earn your graduate degree(s)?
14. What is your current position in the university?
15. In what year did you graduate from High School?

Based on the responses received from the professors, a preliminary questionnaire, interview protocol, and observation protocol were created by me and Dr. Jamie Jensen, a biology education researcher and faculty member at Brigham Young University. The questionnaire would allow instructors to document their past educational experience, the interview would determine why they teach the way they do (qualitative), and the observations would determine how the instructors teach today. We decided to create 5 questions which would determine how student-centered an instructor's teaching practice was. These 5 questions focused on the behaviors of the teacher, the behaviors of the students, the method of delivery, how much time was centered on the instructor vs. the students, and how often in-class assessments were given.

These 5 questions were the same for the questionnaire and the observation protocol, in order to directly correlate how teachers teach now to how they were taught.

The same faculty members who were initially interviewed took our new questionnaire and agreed to be observed. We video recorded the instructors teaching a full class period and coded their responses to the questionnaire. We used this sample set of data to analyze and change our instruments before the final study began. Based on the results from questionnaires and observations, we were able to create our final products used in this study. To do this, we read through participant responses to determine whether the questions were easily understandable and whether participants knew exactly what we were asking. We modified questions to be clearer and to elicit more direct responses. Particular attention was given to the clarity of the questions as well as the length of the questionnaire. The questionnaire needed to require a minimal amount of each participant's time while still being thorough. As the questionnaire was altered, so was the observation protocol, so that they were exactly alike. We also determined if we were able to easily code the 5 questions from the questionnaire and observation protocol into a quantifiable scale to fit our desired statistical analyses. Last, this preliminary trial gave us an insight into various variables that might impact teaching practices, and which we could survey for in our actual study.

Questionnaire

Each participant, after receiving and signing a copy of the consent form, answered an online questionnaire. This questionnaire asked them to evaluate or self-report on three different categories of instructors: their instructor's teaching practices in the introductory biology, introductory chemistry, or introductory physics class that the participant took in his or her own education, their instructors' teaching practices in their own core science classes, and their instructors' teaching practices in their general education classes. These three different categories were chosen because they were three main areas the participants in our preliminary trial mentioned as being influential. We could not have them evaluate every single teacher they had ever had separately, but it was proposed that these three categories adequately covered an individual's past educational experience. We were also curious to see the differential influences of the instructor of the course they now teach versus instructors of core science and GE classes. For example, Dr. Brown took Dr. Thompson's introductory biology class, but does Dr. Brown teach more like Dr. Thompson's teaching method, or maybe like his average teacher for his other core sciences classes? We also asked them to answer the same five questions for their own teaching methods, in order to evaluate how well participants self-report compared to the ratings given through observations.

This part of the questionnaire was coded using numerical equations created by myself, and all the coding for this section was done solely by me. Each question is displayed below in Table 2 with the area evaluated and the equation used. The scores for all 5 questions were summed together into one total. Based on the answers given in this part of the questionnaire, each category received a single, student-centered score. (See Appendix for full Questionnaire.)

Table 2. Five questions created for questionnaire and observation protocol, with area addressed and equations for coding.

Question #	Criterion Measured	Equation
1	Behaviors of instructor	*(Answer # - 1)*5 = score*
2	Behaviors of students	*(Answer # - 1)*5 = score*
3	Method of delivery	*(Lecture % / 100) * 20 = score*
4	Time focused on instructor vs. time focused on students	*(Student % / 100) * 20 = score*
5	Frequency of in-class assessments	*(Answer # - 1)*5 = score*
		Sum of Scores ____

Last, the questionnaire asked questions about each subject's pedagogical background, experience, and knowledge as well as demographic questions. This part was divided up into continuous variables and categorical variables. Table 3 shows the various variables and options each participant could choose. The questionnaire has 35 total questions. (See Appendix for full Questionnaire.)

Table 3. Continuous variables and categorical variable addressed in questionnaire, as well as the options given.

Variable	Options
Number of pedagogical classes, workshops and meetings	#
Do you attend other colleagues' classes?	Not at all, Occasionally, Frequently
Do you read pedagogical books or journals?	Not at all, Occasionally, Frequently
Do you discuss pedagogical techniques with peers?	Not at all, Occasionally, Frequently
Age	#
Years since own education	#
Class size	#
Year teaching total	#
Total years teaching this course	#
Position at school	Professor, Associate Prof., Assistant Prof., Instructor, Adjunct, Grad Student
Educational Degree	PhD, MD, MS, BS
School currently working at	BYU, UVU, U of U, WSU, USU, SC, SLCC
Subject matter	Biology, Chemistry, Physics
Gender	Male, Female

Interviews

Each subject was then interviewed during the semester, in order to determine their views on why they teach the way they do as well as what influences their teaching practices. Table 4 details the questions used in the interview. Again, these questions were selected after interviewing faculty members in the Life Sciences Department at Brigham Young University and evaluating from those responses what factors most commonly seem to influence an instructor's teaching practices. The questions were designed to get instructors thinking about their teaching practices, and then to elicit any perceptions or influences on an instructor's teaching practice. (See Appendix for full Interview Protocol.)

Table 4. Interview questions from interview protocol.

Interview Questions
1. What is your full name?
2. Which introductory class are you teaching this fall?
3. Briefly describe to me the teaching methods you use in this class.
4. Why do you teach the way you do?
5. What in your past influences the way you teach this class now?
6. Is there a person who strongly influences the way you teach this class now?
7. Do you have a source of inspiration for the way you teach?
8. Briefly describe to me the teaching methods used in your introductory biology, chemistry, or physics class.
9. Briefly describe to me the overall teaching methods used in your undergraduate education.
10. How has your past education influenced the way you teach now?

Observations

Each subject was observed for three full class periods. The observation dates were randomly chosen throughout the semester; instructors were notified of the observation dates to protect student privacy per IRB requirements. Each subject was evaluated using an observation protocol developed specifically for this study by me and Dr. Jamie Jensen (but inspired by the RTOP), and was identical to the rubric used by each participant in the questionnaire to evaluate their own teaching practices as well as the teaching practices they were exposed to in their own past education (see Table 5). The Reformed Teaching Observation Protocol (RTOP) was influential in our questionnaire design, as it is considered a highly reputable observation protocol (Adamson et al., 2013). However, for my study, the only parameter being measured was how student-centered an instructor's teaching practice was, while the RTOP measures this as well as other parameters, such as instructor patience, lesson content, and respect in the classroom. To narrow my focus to one parameter, a new questionnaire was designed. Also, since each subject would be asked to use this assessment on several different categories of instructors, it needed to be short to reduce participant time and encourage participation.

Table 5. Questions for Observation Protocol.

#	Question
1	On a range of 1-5, which of the following *best* describes what the instructor did? If you feel you are in-between two categories, please select accordingly.
2	On a range of 1-5, which of the following *best* describes what you as the student did? If you feel they are in-between two categories, please select accordingly.
3	During a typical class period, what percentage of time was spent doing one or more of the following:
4	What percentage of class time did students spend speaking to the instructor and/or each other? (It is assumed the remainder of the class time would be the instructor formally lecturing to students).
5	On a range of 1-5, which of the follow *best* describes how often in-class assessments (such as short quizzes, writing exercises, problem-solving practices, etc.) were administered? If you feel they were administered in-between two categories, please select accordingly.

The new Observation Protocol measures how "student-centered" the subject's teaching method is. Student-centered teaching was defined as "the arrangement of the teaching experience focusing on the students' responsibilities and activities in the learning process which takes into consideration the students' interests, demands and needs" (Cubukcu, 2012, pg. 49). Nothing else was measured in this study, in order to narrow the focus to one variable.

The protocol is divided into 5 questions. For each question, a subject could receive between 0 and 20 points. For the 5 categories combined, the lowest score possible is 0 and the highest score possible is 100. The higher the score, the more student centered an instructor's teaching practices was considered. Each observation was evaluated and scored by two raters; the scores were then averaged together for each observation. The final scores for all three observations were then averaged together into one Independent Rater score for each subject (see Appendix for full Observation Protocol.) This score was placed on a continuous scale to determine how teacher-centered and how student-centered a participant is in their teaching approach. This scale can be seen in Figure 1.

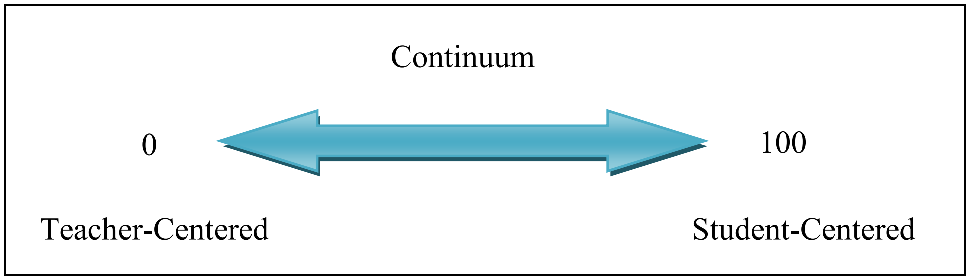

Figure 1. The continuous scale from teacher-centered to student-centered that was used in protocols.

Each observation lasted the entire class period. During the observation, the participant was videotaped. The observer making the recording sat as a student midway between the front and back of the class. The instructor and the students in the front of the room were always on camera. The observer did not interact with the instructor or students, but was a bystander. Students were informed of the observation dates, and those who did not want to be videotaped were advised to sit behind the observer. I was a rater as well as undergraduates in Dr. Jamie Jensen's biology education lab. I trained each rater in multiple meetings. I was a rater for every observation. One of the six trained undergraduate students in the lab was the second rater, who was chosen at random for each observation.

Statistical Analyses

A paired samples t-test was used to compare each participant's Independent Rater score (obtained from observations) with the self-reported score of the participant. This was done simply to asses self-reporting accuracy. A simple linear regression was also used to see if participants understood the parameter we were measuring (which would be shown by a high correlation).

A paired samples t-test was used to compare a participant's Independent Rater score with the scores given by each participant to their past instructor who taught the class most similar to the one that was used in this study (ex. the instructor to their past introductory biology, chemistry, or physics class), the instructors for their core science classes, and the instructors for their GE classes. A paired samples correlation was also used to visualize the comparison. This was done to answer the question: do teachers teach the way they were taught?

Linear regression, ANOVA, and multiple regression analyses were also used to compare the various factors surveyed with the Independent Rater score, to determine if any factors could significantly predict an Independent Rater score.

Privacy of Participants

All data were kept in a locked room on a password protected computer. Personal information was removed from questionnaires, interviews, and observations after they were collected. Each participant was referred to by a special coded number, making each anonymous. All data were handled directly by me. The trained undergraduates who provided the second rating on the observations were able to access only the specific the videos they observed. They were not allowed access to any other data, including personal information about the participants.

RESULTS

Self-Report

A paired-samples t-test comparing scores given by independent raters and scores from self-report was conducted to evaluate whether instructors accurately self-report. The results indicated that the mean score by the Independent Rater(s) ($M = 31.83$, $SD = 16.21$) was significantly lower than the mean score by the subject ($M = 44.82$, $SD = 17.90$). The mean difference between the score given by the Independent Rater and the score self-reported by the instructor was 12.99 points ($p < .001$). Refer to table 6.

Table 6. Paired samples t-test mean, confidence interval, and *p*-value for self-report and independent rater score. The independent rater score was significant lower than the self-report score.

	Paired Samples t-test		
	Mean	95% Confident Interval	*p*-value
Self-Report vs. Independent Rater	12.988	(9.501, 16.475)	< .001

A simple linear regression was conducted to evaluate whether instructors understood the parameter we were measuring, i.e., whether independent rater's scores were correlated with self-report scores such that those with low scores by raters also rated themselves low, and vice versa. The results, including a Pearson's correlation, indicated that the mean score given by the independent raters and the mean score given by the subjects were significantly correlated, R = .784, slope = 0.865 (p <.001) (See Figure 2). While the Independent Rater scores were correlated with the scores by the subject, signifying that they did in fact understand the parameter we were measuring, the subjects tended to inflate their own score an average of 12.99 points.

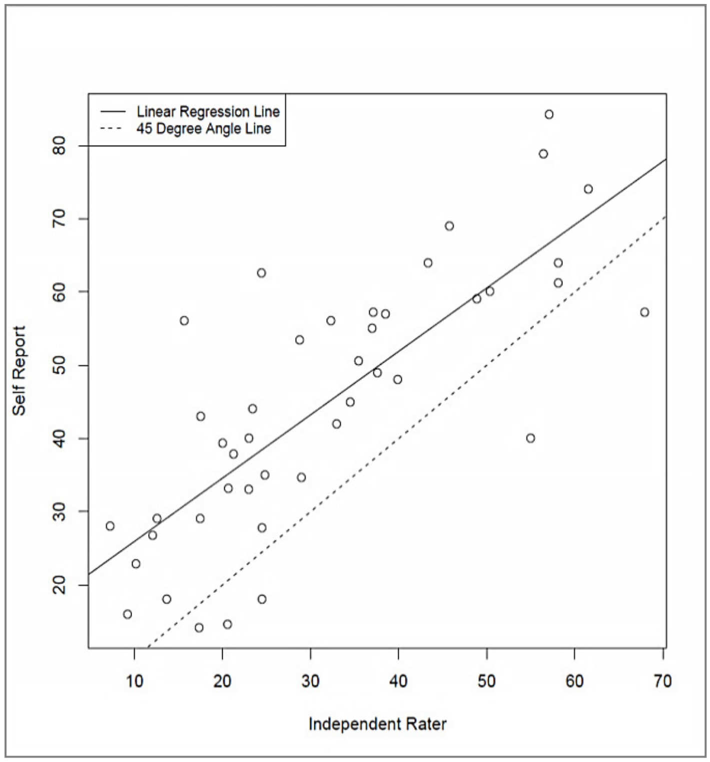

Figure 2. Linear regression fit between self-reported score and independent rater score, showing high correlation between the two variables (R = .784).

Past Educational Experience

A paired-samples t-test, simple linear regression, and Pearson's correlation were conducted to compare the way each subject teaches to the way they were taught by the following individuals: their past instructor for the class most similar to the one they teach now, their instructors for core science classes, and their instructors for GE classes. The results from the paired-samples t-test indicated that the mean teaching method used by the subjects ($M = 31.83$, $SD = 16.21$) is significantly greater than the mean teaching method used by their past instructor of the course they teach now, the instructors of their core science classes, and their GE instructors ($M = 22.36$, $SD = 17.62$, $p = 0.017$; $M = 18.09$, $SD = 12.10$, $p < 0.001$; $M = 18.05$, $SD = 13.67$, $p < 0.001$, respectfully). See Table 7.

The results from the simple linear regression and Pearson's correlation indicated that the teaching method used by each subject is not significantly correlated to the methods used by their past instructor in the course most similar to the one they teach now, the instructors in their core science classes, and their instructors in their GE classes ($R = 0.128$, slope = 0.120, $p = .470$; $R = -0.052$, slope = -0.069, $p = .743$; $R = 0.010$, slope = -0.012, $p = .952$, respectfully). Refer to Figure 3.

Table 7. Paired samples t-test mean, confidence interval, and p-value between independent rater score and each instructor's past instructor, core science classes, and GE classes. The mean teaching method used by the subjects is significantly greater than the mean teaching method used by their past instructors of the course they teach now, the instructors of their core science classes, and their GE instructors.

	Paired t-test		
	Mean	95% Confidence Interval	p-value
Independent Rater vs. Past Instructor	9.708	(1.865, 17.551)	0.017
Independent Rater vs. Core Science Classes	13.745	(7.367, 20.123)	< .001
Independent Rater vs. GE Classes	13.787	(7.229, 20.334)	<.001

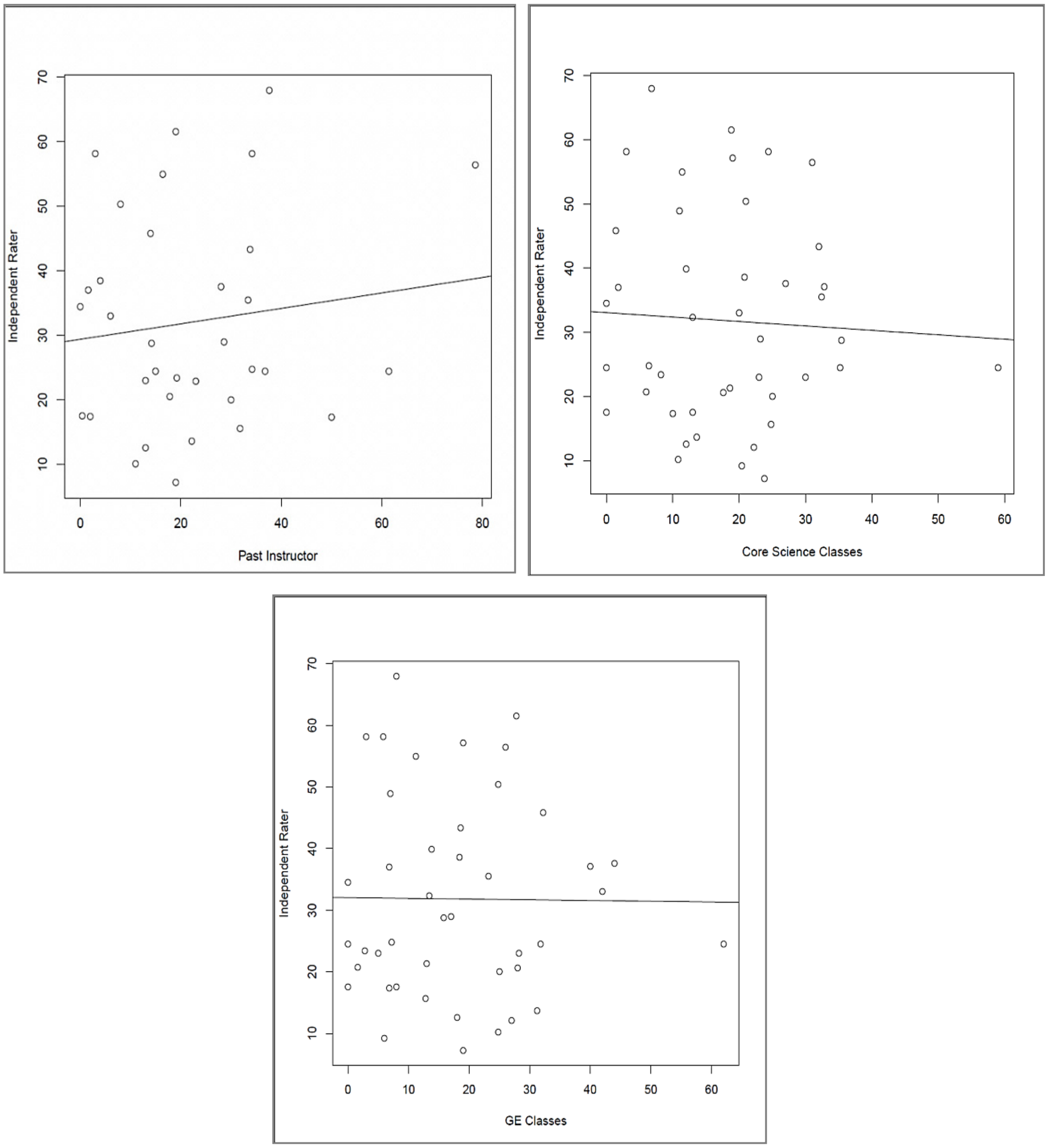

Figure 3. The linear regression between the independent rater score and the scores given by each instructor for their past instructor (R = 0.128, *p* = .470), core science classes (R = -0.052, *p* = .743), and GE classes (R = 0.010, *p* = .952), shows that there is no relationship between the variables.

Factors

The various descriptive data points gathered in the questionnaire were used in simple linear regression models or one-factor ANOVA models to evaluate their ability to predict student-centered approaches. Regression was used for the continuous variables and 1 factor ANOVA was used for the categorical variables, treating each variable separately. The continuous variables included the number of pedagogical classes, workshops and meetings each participant had attended, each participant's age, how many years it has been since their own education, each participant's class size for the class used in this study, how many years they had been teaching, and how many years they had been teaching the particular class used in the study. The categorical variables included how often each participant had attended their colleagues' classes, how often they read pedagogical books or journals, how often they had discusses pedagogical techniques with peers, their position at the institution where they taught, their educational degree, the school at which they taught, which subject they taught, and their gender. The following variables are significant at the 0.05 level: Age, Years Since Degree, Total Years Teaching, Years Teaching Course, and Position. Table 8 shows the statistical output for both the continuous variables and the categorical variables. Table 9 shows the counts for each of the categorical variables.

Table 8. Linear regression and ANOVA for continuous variables and categorical variables. The bolded variables are significant at the 0.05 level: Age, Years Since Degree, Years Teaching Course, and Position.

	Variable	Mean	SD	df	Adj. R-squared	F-statistic	*p*-value
Continuous Variables (Linear Regression)	Num Classes, etc., Attended	11.80	11.36	38*	0.01249	1.493	0.299
	Age	48.51	12.27	41	0.2445	14.59	**<0.001**
	Year Since Degree	15.26	11.43	41	0.1742	9.859	**0.003**
	Class Size	107.72	101.0	41	0.008441	1.358	0.251
	Total Years Teaching	15.07	10.73	41	0.1377	7.708	0.008*
	Years Teaching Course	8.88	8.53	41	0.2695	16.5	**<0.001**

	Variable	df	Sum Sq	Mean Sq	F-value	*p*-value
Categorical Variables (ANOVA)	Attend Colleagues Classes	2, 40	789.1	394.55	1.5394	0.227
	Read Books/ Journals	2, 40	100.7	50.352	0.1841	0.833
	Discuss with Peers	2, 40	71.4	35.72	0.1302	0.878
	Position	5, 37	4681.2	936.23	5.4463	**< 0.001**
	Education Degree	3, 39	543.9	181.30	0.6736	0.573
	School	6, 36	2907.6	484.60	2.1448	0.072*
	Subject	2, 40	19.1	9.545	0.0346	0.966
	Gender	1, 41	1379.2	1379.16	5.8522	0.020*

*Excluding 3 outliers with Num Classes > 100
*Bolded *p*-values are significant at the 0.05 level.
*Starred *p*-values approach significance

Table 9. Categorical variable counts for how often each subject attended colleagues classes, how often they read edagogical books or journals, how often they discussed pedagogical techniques with peers, their school position, their terminal educational degree, the school they teach at, the subject they teach, and their gender. .

Categorical Variables							
Attend	Not at all	Occasionally	Frequently				
Colleagues Classes	13	29	1				
Read	Not at all	Occasionally	Frequently				
Books/Journals	5	28	10				
Discuss with	Not at all	Occasionally	Frequently				
Peers	1	20	22				
Position	Graduate	Adjunct	Instructor	Assistant	Associate	Professor	
	2	14	2	4	8	13	
Educational	BS	MD	MS	PhD			
Degree	3	1	8	31			
School	BYU	UVU	U of U	WSU	USU	SC	SLCC
	19	8	3	2	2	2	7
Subject	Biology	Chemistry	Physics				
	29	8	6				
Gender	Male	Female					
	33	10					

Age of Participants

The age of the instructor was compared to their teaching rating using linear regression. A participant's age was a significant factor in predicting Independent Rater score at the 0.05 level in the linear regression. The equation for the simple linear regression line is:

(Independent Rater) = 64.68 – (0.68) (Age)

The equation can be interpreted as follows: For an age of zero (hypothetically) the average Independent Rater score is 64.68. For every one year increase in Age, there is an average decrease in Independent Rater score of 0.68. In other words, older participants were less likely to teach in a student-centered way. The correlation between these two variables is -0.51. Figure 4 shows the regression between the two values.

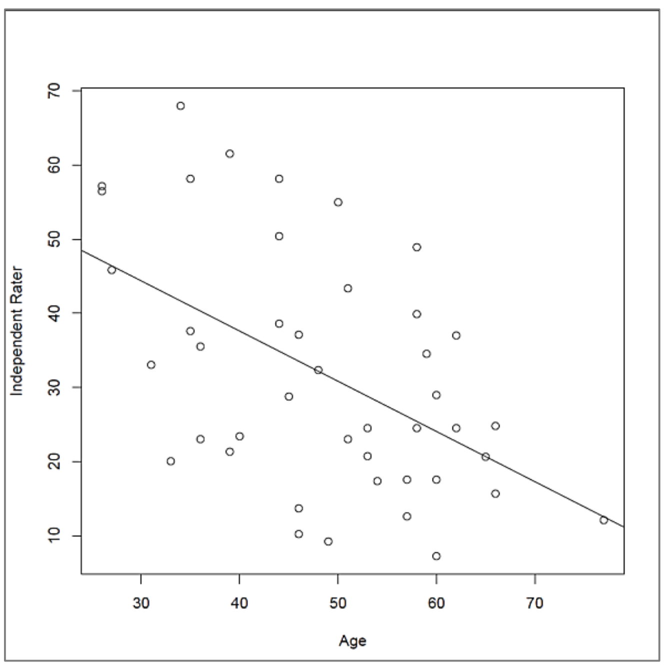

Figure 4. A linear regression line between Independent Rater score and Age, showing that older participants were less likely to teach in a student centered way, R = -0.51, $p < 0.001$.

Years Since Degree

The years since the participant obtained their terminal degree was compared to their teaching rating using linear regression. This was a significant factor in predicting Independent Rater score at the 0.05 level. The equation for the simple linear regression line is:

(Independent Rater) = 41.36 – (0.62)(Years Since Degree)

The equation can be interpreted as follows: For zero Years Since Degree (i.e., their first semester since graduating), the average Independent Rater score is 41.36. For every one year increase in Years Since Degree, there is an average decrease in Independent Rater score of 0.62. As more time passed since participants' had obtained their terminal degree, participants were less likely to teach in a student-centered way. The correlation between these two variables is -0.44. Figure 5 shows the regression between the two values.

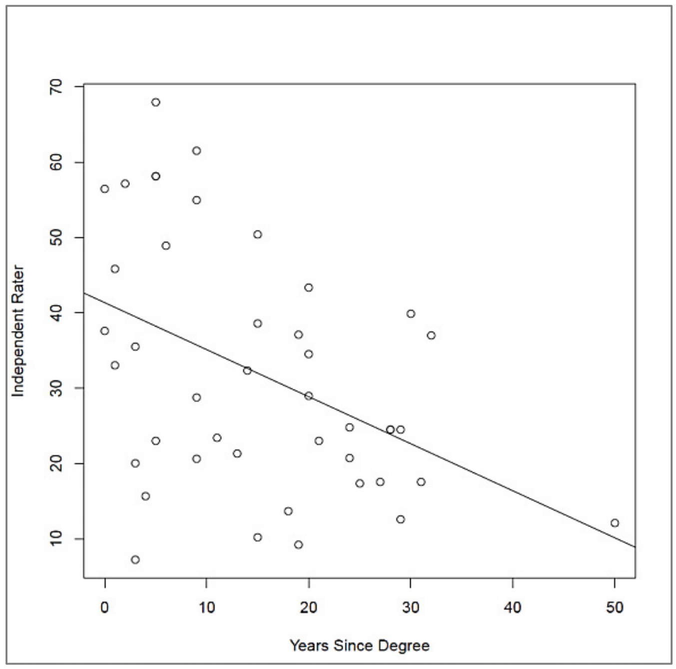

Figure 5. A linear regression line between Independent Rater score and Years Since Degree showing that as more time passed since participants' had obtained their terminal degree, participants were less likely to teach in a student-centered way, R = -0.44, *p* = 0.003.

Years Teaching Course

The years a participant has taught the particular course that was observed in the present study was compared to the participant's average teaching rating using linear regression. This variable was a significant factor in predicting Independent Rater score at the 0.05 level. The equation for the simple linear regression line is:

(Independent Rater) = 40.87 – (1.02) (Years Teaching Course)

The equation can be interpreted as follows: For zero Years Teaching Course (i.e., this was their first time teaching the course), the average Independent Rater score is 40.87. For every one year increase in Years Teaching Course, there is an average decrease in Independent Rater score of 1.02. Participants who had been teaching the particular course used in this study for a longer period of time were less likely to teach that course in a student-centered way. The correlation between these two variables is -0.54. Figure 6 shows the regression between the two values.

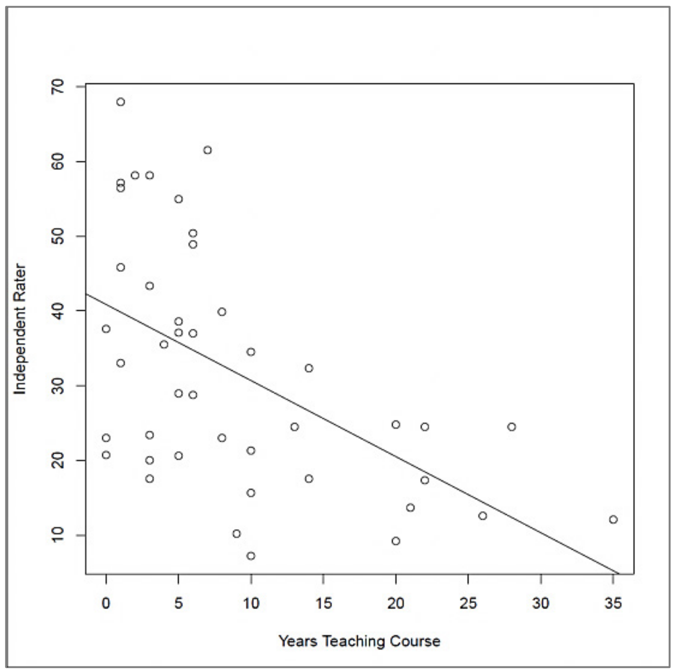

Figure 6. A linear regression between Independent Rater and Years Teaching Course, showing that participants who had been teaching the particular course used in this study for a longer period of time were less likely to teach that course in a student-centered way.

Summary of Continuous Variables

It is important to note here that the correlation between all of the significant continuous variables is very high (see Figure 7), meaning these variables are very interrelated variables (R-values: Age vs. Years Since Degree = 0.727, Age vs. Years Teaching Course = 0.604, Years Since Degree vs. Years Teaching Course = 0.682). However, this is exactly what we would expect given that all four deal with time.

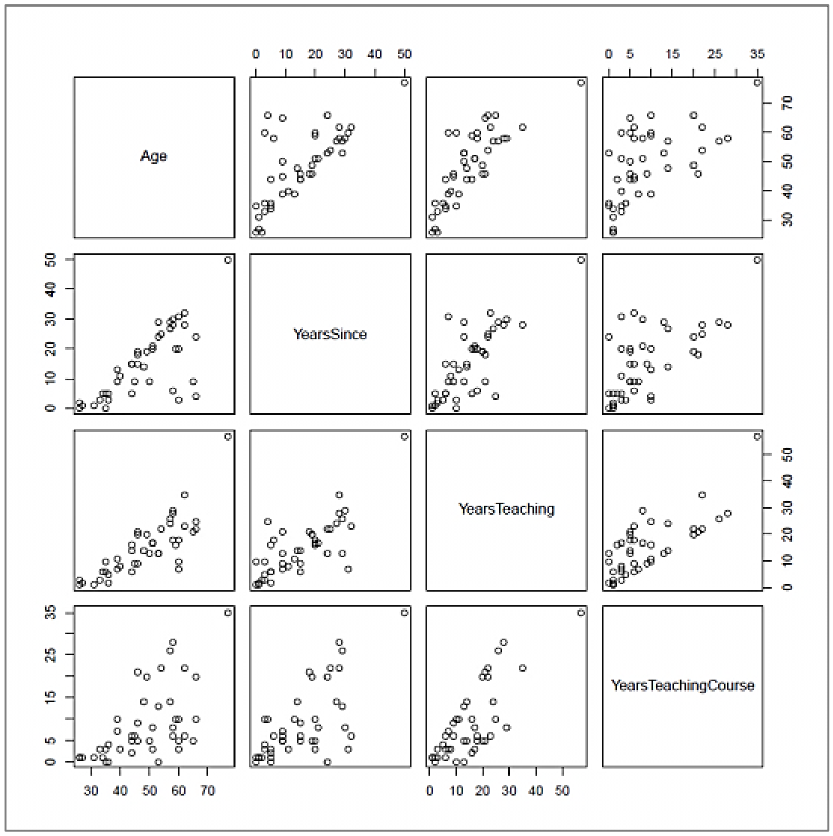

Figure 7. Correlation between Age, Years Since Degree, Years Teaching, and Years Teaching Course., showing that each variable is highly correlated to each other. (R-value: Age vs. Years Since Degree = 0.727, Age vs. Years Teaching Course = 0.604, Years Since Degree vs. Years Teaching Course = 0.682)

Position of Participants

We compared the current academic position of each participant with their average teaching rating using ANOVA. There is a significant relationship between a participant's position and Independent Rater score at the 0.05 level. The mean Independent Rater Score for each Position can be seen in Table 10.

Table 10. Mean Independent Rater Score, standard deviation, and count for each Position**.**

Position	Mean	SD	Count
Grad Student	51.42	7.997	2
Adjunct Faculty	35.44	16.19	14
Instructor	19.31	5.176	2
Assistant Professor	55.14	15.32	4
Associate Professor	26.346	13.72	8
Professor	23.00	8.362	13

An ANOVA was significant, F(5) = 5.446, $p < 0.001$. Post hoc pairwise comparisons using the Bonferroni correction for alpha inflation (corrected p-value = 0.0036) show that Assistant Professors (M = 55.14, p = .014) have higher scores than both Associate Professors (M = 26.35) and Full Professors (M = 23.00; p =.014 and .002, respectively) (refer to Table 11 for all comparisons). See Figure 8 for boxplot comparisons.

Table 11. Post hoc p-values of the pairwise difference between positions adjusted for multiple testing using the Bonferroni method. Bolded values are significant at the 0.05 level.

	Adjunct faculty	Assistant professor	Associate Professor	Graduate Student	Instructor
Assistant professor	0.129				
Associate Professor	0.785	**0.014**			
Graduate Student	0.785	1.000	0.186		
Instructor	0.785	0.041	1.000	0.186	
Professor	0.186	**0.002**	1.000	0.084	1.000

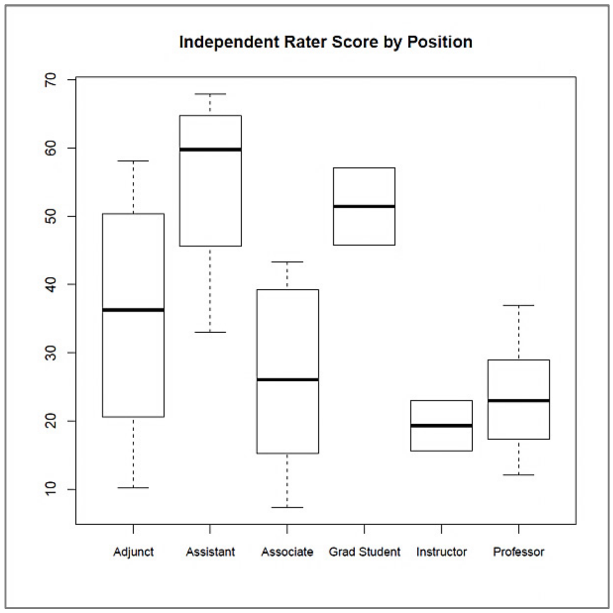

Figure 8. Boxplots of Independent Rater score by Position. Assistant Professor is significantly higher than Associate Professor and full Professor.

Interrater Reliability

Two raters scored each observation, in order to increase accuracy and prevent bias. To determine interrater reliability, a simple linear regression was performed to determine consistency among raters. The interrater reliability for the raters was found to be r = .868, slope = 0.711, $p < .001$. In addition, a Pearson's Correlation (r=.868), Spearman's (r = .827), and Kendall's (r = .66) indicate that interrater reliability was consistent at the .01 level. This high correlation between raters indicates that if one rater scored a participant low, the other rater did as well, and if one rater score a participant high, the other rater did as well. See figure 9 for linear regression between raters.

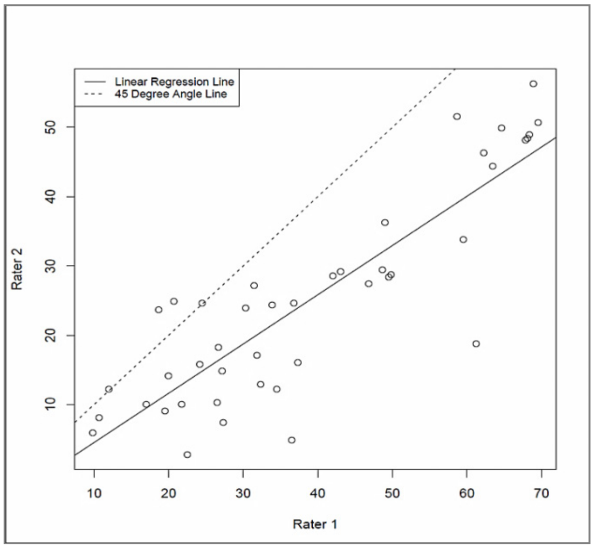

Figure 9. Linear regression line fitted between raters, R = 0.868, slope = 0.711, $p < 0.001$.

A paired samples t-test was conducted to evaluate whether any bias existed between the raters. The results indicated that the mean score for Rater 1 (M = 38.96, SD = 18.39) was significanlty greater than the mean score for Rater 2 (M = 25.10, SD = 15.06). The mean difference between raters was 13.86 (see Table 12). However, while one rater scored higher than the other, the scoring was consistent, showing that all participants were rated equally.

Table 12. A paired samples t-test comparing two raters, showing that rater 1 was significantly higher than rater 2.

	Paired t-test		
	Mean	95 % Confidence Interval	*p*-value
Rater 1 vs. Rater 2	13.857	(11.033, 16.682)	< 0.001

Interviews

Each subject was asked why they teach the way they do and what influences them in a series of open response questions. (See Appendix for the full survey instrument.) Each participant mentioned multiple reasons for why they teach the way they do and what influences them. Below is the range of their responses:

1. I prefer to be taught this way
2. I liked a particular way my teacher taught
3. I teach the way I myself learn
4. I emulate good teachers I have had
5. I try not to follow the example of bad teachers I have had
6. I think students learn better/best this way
7. I teach this way so that students will be more likely to remember the material
8. I try to spark students' interest
9. I had an advisor or teacher who taught me a better way to teach
10. I had a teacher who taught me a better way to teach
11. I borrowed ideas from peers
12. I learned how to teach by talking to my spouse
13. I enjoy teaching this way
14. I have a large class and logistically this is the way I have to teach
15. I have a large amount of material to cover and logistically this is the way I teach
16. I used trial and error in the classroom until I found something that worked for me

Each subject stated multiple reasons for teaching the way they do. Responses from the participants were analyzed and categorized into 10 common response categories. The categories are shown in Table 13, along with the number of participants who stated each reason.

Table 13. Common response categories to the question, “Why do you teach the way you do?” with response numbers. The most common response was “I teach the way I prefer to be taught” and “I teach the way I think students learn better/best.”

Reasons	Total Number
I teach the way I prefer to be taught	33
I teach the way I think students learn better/best	30
I use past experience in my classroom, such as trial and error	16
I have a large class and logistically this is the way I have to teach	14
I borrowed ideas from my peers	14
I enjoy teaching this way	11
I learned from conferences, workshops, and classes	8
I learned from reading books	6
I had an advisor or teacher who taught me a better way to teach	5
I teach how my teachers taught	5

Most of the subjects (N = 33, 77%) stated they teach the way they preferred to be taught when they themselves were in school. Similar statements to this idea are that they emulate good teachers they had and try not to follow the example of bad teachers they had, they teach the way they themselves learn best, or they liked the way a particular teacher or advisor taught. Most of the participants (N = 30, 70%) mentioned they teach the way they think students learn better or best. A similar statement was that students will most likely remember the material if the instructor teaches this way, or that the teacher teaches this way to spark interest and learning in the students. The next largest response category (N = 16, 37 %) was that the participants teach according to their own past experience in the classroom, seeing what works and what doesn’t (trial and error). About half of the participants (N = 14, 33 %) mentioned that they borrowed ideas from peers or advisor, either through conversation or observation, and included in this number are those who mentioned an influential spouse. There was a similar number (N = 14, 33%) who said that due to the logistical constraints of the class (number of students, amount of content, or time), this was the easiest/best way for them to teach. There were 11 participants (26%) who said they teach this way because they enjoy it, and 8 people (19%) said that they learned to teach from conferences, workshops, and classes. A small number (N = 6, 14 %) said they learned to teach from reading books, five (12%) said an advisor or teacher taught them a better way to teach, and five (12%) said they teach the way they do because that is how their teachers taught it to them. See Figure 10 for percent totals of each category.

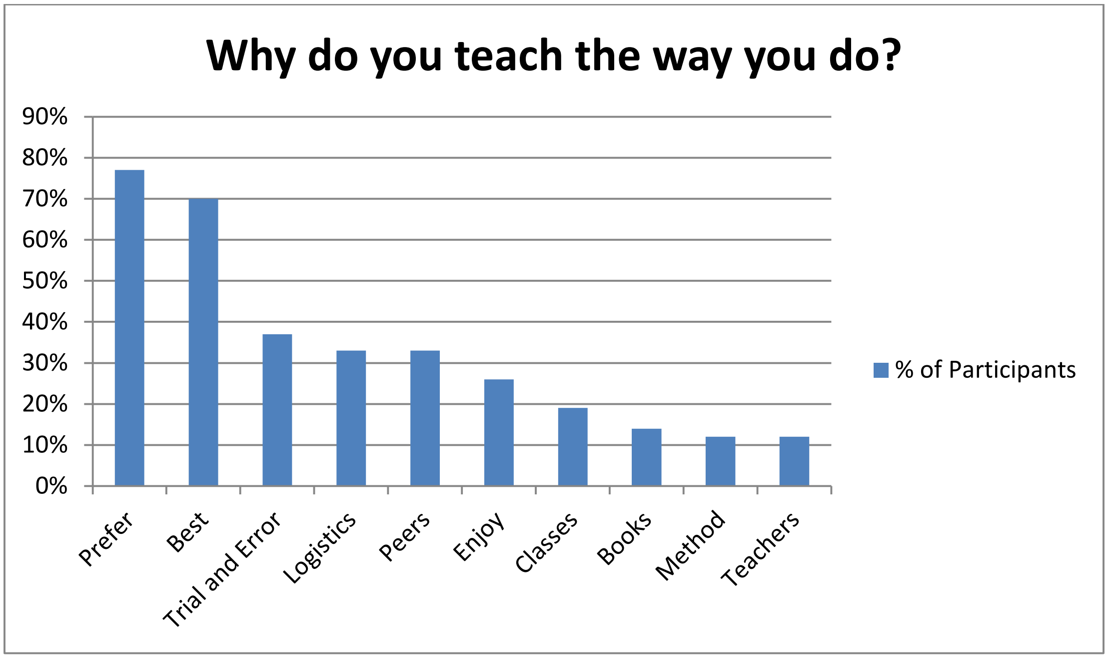

Figure 10. Graphical representation of the percentages of each response category.

DISCUSSION

This study is the first to take a quantitative approach to how past educational experience affects the teaching practices of higher education instructors. Our data, surprisingly, does not support the idea that teachers teach the way they themselves were taught. Because of the nature of the experiment and the statistical analyses used, we cannot say that teachers *do not* teach the way they were taught, simply that there is no relationship between the way they were taught and the way they teach now. It is important to note that we measured three groups of instructors: the instructor who taught the participants the material in a class similar to the one the participants teach now, the instructors who taught the participants their core science classes, and the instructors who taught the participants their general education classes. It is possible that other groups of instructors may have played an influential role that is not being captured here; more research needs to be done in this area.

On the other hand, our data does support a recent study by Ebert-May et al. (2011) on self-report among teachers. In this study, after instructors of science classes for graduates attended professional development programs which aimed to help them teach in a more student-centered way, these same instructors were asked to self-report on surveys. Questions included their satisfaction with the workshops, what they learned, and how they had implemented what they had learned into their classroom. 89% of the instructors said that they had altered the way they taught to a more student-centered teaching method. However, when they were observed and coded with the RTOP, the authors found that 75% of the instructors actually taught using a more teacher-centered approach. In our study, we found that while Independent Rater scores and self-report scores were highly correlated (meaning that participants that the raters scored lower also scored themselves lower, and the participants that the raters scored higher also scored themselves higher on our scale), the instructors tended to inflate their own scores. We can conclude that higher-education teachers at colleges and universities seem to think they are teaching in a more student-centered way than they really are. This could be because teachers group all their lessons together as one in their mind, counting the number of student-centered methods, and not considering each class period individually. However, it is important to note that only three full class periods were observed per participant, which gives us a good idea of how they teach but still provides a small sample of their teaching methods. It is possible that when instructors self-report, they have a better idea of their own teaching methods than we can gather from limited observations.

From the various descriptive factors we investigated, there are some interesting results. A participant is less likely to teach using student-centered teaching methods if they are older, if it has been longer since they obtained their terminal degree, and if they have been teaching an introductory biology, chemistry, or physics class for a longer period of time. This could be interpreted in two ways: either faculty members are becoming more teacher-centered in their teaching methods as they age and teach for a longer period of time, or those faculty members that are currently older and have been teaching for a longer period of time were less likely to be exposed to a more student-centered way of teaching. The latter reason would be expected, since the movement away from teacher-centered approaches in higher education is relatively recent (Freeman et al., 2014). If this were so, it would be encouraging that the newer, younger faculty members are more likely to teach in a student-centered way, as they are the future of our current universities and colleges. If they continue to teach in a more student-centered way, then the future education of our undergraduates is looking up. However, it would be interesting to conduct a longitudinal study to see if, in fact, faculty members use less student-centered teaching methods as they age.

Even more interesting is that a faculty members' position can heavily influence their teaching style or effort. Our data supports that Assistant Professors are much more likely to teach using student-centered teaching methods than Associate Professors and full Professors. Assistant Professors are usually younger than Associate Professors and full Professors and have been teaching for a smaller amount of time. Assistant Professors also have more pressure to teach well, given that they have not yet received tenure at their institution and teaching is one of the categories on which they are evaluated. Associate Professors and full Professors, on the other hand, have obtained tenure and may be relaxing a little on their quality of teaching. However, tenure is decided not only on teaching but also on research, funding, and service. Teaching may not carry as much weight as the other areas in deciding tenure position. It could also be that introductory classes are more likely to be assigned to new faculty, who might be more enthusiastic about teaching, and older faculty, who may be worn out. Further research is needed to pinpoint exactly why Assistant Professors teach in a more student-centered way.

One of our most important findings comes for our qualitative data. Our data proposes a new hypothesis for why teachers teach the way they do. Instead of teachers teaching the way they were taught, they teach the way they *preferred* to be taught. Similar to this idea is that teachers teach the way they think students learn *best*, which is also influenced by how teachers think they learn best. In other words, our teachers are not computers that simply regurgitate what they have experienced but are selective in how their past experience in their own education influences their current teaching practices. The idea that teachers teach the way they were taught is very much a behaviorist point of view; a teacher was exposed to a certain teaching behavior in their own education, and so they will exhibit this behavior when they themselves teach. However, our data shows us that this is not the case. When teachers teach, they go through a metacognitive process where they reflect on the way they were taught and if that worked for their own learning, and whether they liked certain methods they were exposed to. They pick up methods from teachers they liked and avoid methods from teachers they disliked. They are more likely to use a certain method if it worked for them and they had a positive experience with it. It is important to note that this is not true for all teachers. Some, because of logistics or being comfortable with the way things are, mimic a past instructor in a behavioral way. However, for most teachers, instead of just teaching the way they were taught the material, they are consciously tailoring their teaching to meet the needs of the students as they perceive them.

Future Research

There are many possible implications for reform from our findings. Reform in teaching is difficult (Herrington et al., 1999). A large amount of time, money, and research has been spent on preparing pre-service teachers to teach and on professional development programs for higher education faculty members. Some programs, such as ACEPT, have been successful in promoting reformed teaching and some have not (Adamson et al. 2003; Herrington et al., 1999). In our own study, only 7 % of the faculty members interviewed mentioned classes, workshops, and conferences as influencing the way they taught, despite the emphasis being put on Professional Development by AAAS, NRC, NSF, etc.

Based on our findings, we propose a unique approach to helping higher education faculty members reform to a more effective teaching method. Teachers should be allowed to go through the same metacognitive process that they do when deciding how to teach a particular lesson, only with student-centered learning. In most professional development classes as well as workshops, pedagogy is usually taught and demonstrated using content that the teacher teaches on a regular basis, such as balancing chemical equations or diagramming the process of cellular respiration. The teachers observe and learn and appear to accept reform, but then many do not change the way they teach. Instead, it could be more effective to teach and demonstrate proper pedagogy using a subject that the teachers are not as familiar with. Of course, teaching difficult content would create unnecessary cognitive load. The content would need to be something the teachers had reviewed recently but simple enough that they would be able to participate easily in the learning process. The goal would be for the teachers to learn something new and actually experience learning through a student-centered teaching method. They would then be able to go through the metacognitive process that they went through in their past education and reflect on the way they were taught, if it worked for their own learning, and if they liked it. The student-centered teaching method would then be a part of their repertoire of teaching methods to choose from when preparing a lesson. Teachers would be much more likely to believe that teaching in a student-centered way actually helps student learn because they have experienced it for themselves.

However, it would be better if those teachers had had this experience earlier in their careers. It is still important to use current, evidence based pedagogy in STEM courses in which our future teachers are enrolled. If students first learned the material in a successful, student-centered way, then they would be more likely to use that method of teaching later on in their lives. In a way, these students would 'teach the way they were taught,' not because that was simply the way they were taught, but because the students had a positive experience and found that it was effective in their own learning process. They have already gone through the metacognitive process while in their own education, long before first teaching a class. However, when they do teach and draw upon their own experience as a student, they will be more likely to teach in a student-centered way. These teachers would then be less likely to need education reform as teachers. Based on our findings, it is our hope that education for our undergraduates is improving, and will continue to improve through the years.

Limitations

We recognize that teaching methods alone are not the only important factor in teaching students to learn. The personality of the instructor can have a large impact on student interest and subsequently on student learning, as well as how interesting the material is to the students, what time of day the class is taught, class size, if the students have received adequate rest, how skilled the instructor is at the teaching method chosen, etc. We are also not trying to claim that instructors who received a low Independent Rater score are poor teachers from which students do not learn. Rather, we can only conclude that they do not teach in a student-centered way, which has been shown to be more effective (Freeman et al., 2014). It would have been more informative to pull student evaluations and determine if there is a correlation between student perception of teaching quality and our measure of student-centeredness. We also recognize that, due to the nature of our study, we were not able to use a validated assessment such as the RTOP. However, we believe that our findings are still valuable coupled with the qualitative data gathered. We were able to propose a new hypothesis that can be tested in the future.

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APPENDIX

Questionnaire

Thank you for taking this survey! The first set of questions will deal specifically with the particular course that you are teaching Fall 2013, which is involved in this research (example, Introductory Biology or Physics or Chemistry). The second set of questions will deal specifically with the same course you took in your own education (example, some kind of elementary/basic biology or physics or chemistry class). The third set of questions will ask you about your overall undergraduate education. From there, the rest of the questions are self-explanatory. Please answer honestly. No one important will be looking at your answers, and personal bias will affect the data. Good luck!

1. What is your full name?
2. Which introductory class do you teach?

Please answer the following questions specifically about the particular course you are teaching Fall 2013,which is involved in Stephanie Cox's research (example: Introductory Biology or Physics or Chemistry).

3. On a range of 1-5, which of the following best describes what you do as the instructor? If you feel you are in-between two categories, please select accordingly.
    a. 1=You stand at the front of the room and deliver material via lecture through overhead/slides/PowerPoint presentations and/or writing on the board.
    b. 2=You stand and deliver a lecture, but also walk around the room and/or pause to ask questions of the students.
    c. 3=You explain concepts through lecture-style, but also spend a significant amount of time actively engaging students in peer to peer discussions throughout the class period.
    d. 4=You equally divide the class period between individual/group work by students and instruction via lecture.
    e. 5=You mostly engage students through a variety of individual/group work, walk around as a facilitator, and spend a very small amount of time explaining concepts via lecture.
4. On a range of 1-5, which of the following *best* describes what your students do? If you feel they are in-between two categories, please select accordingly.
    a. 1=Your students listen to you, the instructor, for the full class period.
    b. 2=Your students listen to the instructor but also ask you, the instructor, questions and answer questions posed by you, the instructor.
    c. 3=Your students listen to you, the instructor but also spend a significant amount of time discussing concepts with each other and you, the instructor.
    d. 4=Your students listen to you, the instructor, but also spend an equal amount of time involved in group work with each other.
    e. 5=Your students spend the majority of the class period actively engaged in group-work and spend very little time listening to you, the instructor.

5. During a typical class period, what percentage of time is spent doing one or more of the following: (Values must total 100%)

a. Lecture ____
b. Class Discussions ____
c. Demonstrations ____
d. Activities ____
e. Discussion with group or neighbor ____
f. Concept application ____
g. Journal article discussions ____
h. Problems to solve ____
i. Short writing exercises ____
j. Design and conducting experiments ____
k. Student presentations ____
l. Case studies ____
m. Videos ____
n. Quizzes ____
o. Total____

6. What percentage of class time do students spend speaking to the instructor and/or each other (It is assumed the remainder of the class time would be you, the instructor, formally lecturing to students).
   a. % Student time ______
7. On a range of 1-5, which of the follow *best* describes how often in-class assessments (such as short quizzes, writing exercises, problem-solving practices, etc.) are administered. If you feel they are administered in-between two categories, please select accordingly.
   a. 1=Never
   b. 2=A few times during the semester
   c. 3=Every other week
   d. 4=About every week
   e. 5=Almost every class period

Please answer the following questions specifically about the course you took during your educational experience which is *most similar* to the one you currently teach (example: introductory/basic biology or physics or chemistry class).

8. On a range of 1-5, which of the following *best* describes what the instructor did? If you feel you are in-between two categories, please select accordingly.
   a. 1 = The instructor stood at the front of the room and delivered material via lecture through overhead/slides/PowerPoint presentations and/or writing on the board.
   b. 2 = The instructor stood and delivered a lecture, but also walked around the room and/or paused to ask questions of the students.
   c. 3 = The instructor explained concepts through lecture-style, but also spent a significant amount of time actively engaging students in peer to peer discussions throughout the class period.
   d. 4 = The class period was equally divided between individual/group work by students and instruction by the teacher via lecture.
   e. 5 = The instructor mostly engaged students through a variety of individual/group work, mostly walking around as a facilitator, and spending a very small amount of time explaining concepts via lecture.
9. On a range of 1-5, which of the following *best* describes what you as the student did? If you feel they are in-between two categories, please select accordingly.
   a. 1 = The students listened to the instructor for the full class period.
   b. 2 = The students listened to the instructor but also asked questions of the instructor and answered questions posed by the instructor.
   c. 3 = The students listened to the instructor but also spend a significant amount of time discussing concepts with each other and the instructor.
   d. 4 = The students listened to the instructor but also spend an equal amount of time involved in group work with each other.
   e. 5 = The students spent the majority of the class period actively engaged in group-work and spent very little time listening to the instructor.
10. During a typical class period, what percentage of time was spent doing one or more of the following: (Values must total 100%)
    a. Lecture ____
    b. Class Discussions ____
    c. Demonstrations ____
    d. Activities ____
    e. Discussion with group or neighbor ____
    f. Concept application ____
    g. Journal article discussions ____
    h. Problems to solve ____
    i. Short writing exercises ____
    j. Design and conducting experiments ____
    k. Student presentations ____
    l. Case studies ____
    m. Videos ____
    n. Quizzes ____
    o. Total____

11. What percentage of class time did students spend speaking to the instructor and/or each other? (It is assumed the remainder of the class time would be the instructor formally lecturing to students).

a. % Student time ____

12. On a range of 1-5, which of the follow *best* describes how often in-class assessments (such as short quizzes, writing exercises, problem-solving practices, etc.) were administered? If you feel they were administered in-between two categories, please select accordingly.
    a. 1 = Never
    b. 2 = A few times during the semester
    c. 3 = Every other week
    d. 4 = About every week
    e. 5 = Almost every class period

Please answer the following questions about the core science classes you took to get your bachelor's degree.

13. On a range of 1-5, which of the following *best* describes what the instructor did *in general*? If you feel you are in-between two categories, please select accordingly.
    a. 1 = The instructor stood at the front of the room and delivered material via lecture through overhead/slides/PowerPoint presentations and/or writing on the board.
    b. 2 = The instructor stood and delivered a lecture, but also walked around the room and/or paused to ask questions of the students.
    c. 3 = The instructor explained concepts through lecture-style, but also spent a significant amount of time actively engaging students in peer to peer discussions throughout the class period.
    d. 4 = The class period was equally divided between individual/group work by students and instruction by the teacher via lecture.
    e. 5 = The instructor mostly engaged students through a variety of individual/group work, mostly walking around as a facilitator, and spending a very small amount of time explaining concepts via lecture.
14. On a range of 1-5, which of the following *best* describes what you as the student did *in general*? If you feel they are in-between two categories, please select accordingly.
    a. 1 = The students listened to the instructor for the full class period.
    b. 2 = The students listened to the instructor but also asked questions of the instructor and answered questions posed by the instructor.
    c. 3 = The students listened to the instructor but also spend a significant amount of time discussing concepts with each other and the instructor.
    d. 4 = The students listened to the instructor but also spend an equal amount of time involved in group work with each other.
    e. 5 = The students spent the majority of the class period actively engaged in group-work and spent very little time listening to the instructor.

15. During a typical class period, what percentage of time was spent doing one or more of the following *in general*: (Values must total 100%)
    a. Lecture ____
    b. Class Discussions ____
    c. Demonstrations ____

d. Activities ____
e. Discussion with group or neighbor ____
f. Concept application ____
g. Journal article discussions ____
h. Problems to solve ____
i. Short writing exercises ____
j. Design and conducting experiments ____
k. Student presentations ____
l. Case studies ____
m. Videos ____
n. Quizzes ____
o. Total____

16. What percentage of class time did students spend speaking to the instructor and/or each other *in general?* (It is assumed the remainder of the class time would be the instructor formally lecturing to students).
    a. % Student time ____
17. On a range of 1-5, which of the follow *best* describes how often in-class assessments (such as short quizzes, writing exercises, problem-solving practices, etc.) were administered *in general*? If you feel they were administered in-between two categories, please select accordingly.
    a. 1 = Never
    b. 2 = A few times during the semester
    c. 3 = Every other week
    d. 4 = About every week
    e. 5 = Almost every class period

Please answer the following questions about your overall general education classes.

18. On a range of 1-5, which of the following *best* describes what the instructor did *in general*? If you feel you are in-between two categories, please select accordingly.
    a. 1 = The instructor stood at the front of the room and delivered material via lecture through overhead/slides/PowerPoint presentations and/or writing on the board.
    b. 2 = The instructor stood and delivered a lecture, but also walked around the room and/or paused to ask questions of the students.
    c. 3 = The instructor explained concepts through lecture-style, but also spent a significant amount of time actively engaging students in peer to peer discussions throughout the class period.
    d. 4 = The class period was equally divided between individual/group work by students and instruction by the teacher via lecture.
    e. 5 = The instructor mostly engaged students through a variety of individual/group work, mostly walking around as a facilitator, and spending a very small amount of time explaining concepts via lecture.

19. On a range of 1-5, which of the following *best* describes what you as the student did *in general*? If you feel they are in-between two categories, please select accordingly.
    a. 1 = The students listened to the instructor for the full class period.

    b. 2 = The students listened to the instructor but also asked questions of the instructor and answered questions posed by the instructor.
    c. 3 = The students listened to the instructor but also spend a significant amount of time discussing concepts with each other and the instructor.
    d. 4 = The students listened to the instructor but also spend an equal amount of time involved in group work with each other.
    e. 5 = The students spent the majority of the class period actively engaged in group-work and spent very little time listening to the instructor.

20. During a typical class period, what percentage of time was spent doing one or more of the following *in general*: (Values must total 100%)
    a. Lecture ____
    b. Class Discussions ____
    c. Demonstrations ____
    d. Activities ____
    e. Discussion with group or neighbor ____
    f. Concept application ____
    g. Journal article discussions ____
    h. Problems to solve ____
    i. Short writing exercises ____
    j. Design and conducting experiments ____
    k. Student presentations ____
    l. Case studies ____
    m. Videos ____
    n. Quizzes ____
    o. Total____
21. What percentage of class time did students spend speaking to the instructor and/or each other *in general?* (It is assumed the remainder of the class time would be the instructor formally lecturing to students).
    a. % Student time ____
22. On a range of 1-5, which of the follow *best* describes how often in-class assessments (such as short quizzes, writing exercises, problem-solving practices, etc.) were administered *in general*? If you feel they were administered in-between two categories, please select accordingly.
    a. 1 = Never
    b. 2 = A few times during the semester
    c. 3 = Every other week
    d. 4 = About every week
    e. 5 = Almost every class period

Pedagogical Training

23. How many of the following have you attended/taken?

   a. Professional meeting for education
   b. Education workshops
   c. Education seminars
   d. Education classes
24. How often do you sit in on other faculty members' classes and observe them teach?
   a. Not at all
   b. Occasionally
   c. Frequently
25. How often do you read books, articles, or journal articles about education?
   a. Not at all
   b. Occasionally
   c. Frequently
26. How often do you discuss teaching techniques with other faculty members?
   a. Not at all
   b. Occasionally
   c. Frequently
27. Is there any other source that you have gained knowledge about pedagogical techniques? If yes, please describe:

Demographic Questions

28. In what year did you graduate from high school?
29. What year did you graduate with your bachelors?
30. What year(s) did you earn your graduate degree(s)?
31. How many students are in your class?
32. How many years have you been teaching?
33. How many years have you been teaching ***this course***?
34. What is your current position in the college/university?
35. What is your highest degree?

Interview Protocol

Thank you again for participating in our study. For this interview, I will be asking you some questions. Please answer as honestly as you can. Your answers will be recorded so that this interview can be transcribed later. I assure you that your answers will remain confidential; only I will have access to this information, and it will remain in a secure, locked office on a password protected computer for the duration of the study. After the study, it will be stored in this place for two years, after which it will be destroyed appropriately. Your name will never be used in the published study, but you will simply be referred to by a unique ID number or as "a subject." If you have any questions, please feel free to ask me them at any time. If you feel uncomfortable answering a certain question, you are not obligated to.

11. What is your full name?
12. Which introductory class are you teaching this fall?
13. Briefly describe to me the teaching methods you use in this class.
14. Why do you teach the way you do?
15. What in your past influences the way you teach this class now?
16. Is there a person who strongly influences the way you teach this class now?
17. Do you have a source of inspiration for the way you teach?
18. Briefly describe to me the teaching methods used in your introductory biology or introductory.
19. Briefly describe to me the overall teaching methods used in your undergraduate education.
20. How has your past education influenced the way you teach now?

Observation Protocol

Which of the following best describes what the instructor did? Please write a score between 1 and 5. One decimal place may be included (ex. 2.4). ______

1. The instructor stood at the front of the room and delivered material via lecture through overhead/slides/PowerPoint presentations and/or writing on the board.
2. The instructor stood and delivered a lecture, but also regularly asked questions of the students.
3. The instructor explained concepts through lecture-style, but also spent a significant amount of time engaging students in other activities (including discussions) throughout the class period.
4. The class period was equally divided between individual/group work by students and instruction by the teacher via lecture.
5. The instructor mostly engaged students through a variety of individual/group work, mostly walking around as a facilitator, spending a very small amount of time explaining concepts via lecture.

Which of the following best describes what the students did? Please write a score between 1 and 5. One decimal place may be included (ex. 3.6). ______

1. The students listened to the instructor for the full class period.
2. The students listened to the instructor but also regularly asked questions of the instructor and answered questions posed by the instructor.
3. The students listened to the instructor but also spent a significant amount of time doing other activities (including discussing concepts with each other and the instructor).
4. The students listened to the instructor but also spent an equal amount of time involved in individual/group work with each other.
5. The students spent the majority of the class period actively engaged in group-work and spent very little time listening to the instructor.

During a typical class period, what percentage of time was spent doing one or more of the following (NOTE: the percentages need to add up to 100):

Lecture ____
Class Discussions ____
Demonstrations ____
Activities ____
Discussion with group or neighbor ____
Concept application ____
Journal article discussions ____
Problems to solve ____
Short writing exercises ____
Design and conducting experiments ____
Student presentations ____
Case studies ____
Videos ____
Quizzes ____
Total____

What percentage of the class time was the attention on the instructor verse the student?
______ % instructor; ______ % students

In-class assessments (such as short quizzes, writing exercises, problem-solving practices, etc.) were administered: (Please write a score between 1 and 5. One decimal place may be included (ex. 1.7).) ______

1. Never
2. A few times during the semester
3. Every other week
4. About every week
5. Almost every class period