Faculty Perceptions of Teaching in Undergraduate Computer Science Education

Ann Abdelzaher
University of Virginia

Abstract

The purpose of this study is to examine the attitudes of computer science faculty members towards undergraduate teaching. The questions addressed in this study are: (1) How important is effective teaching to computer science faculty members at the undergraduate level and how important do they perceive effective teaching to be to their institution? 2) How much teacher training have computer science faculty members received? 3) What do computer science faculty members believe about teaching? 4) What are the current teaching practices of computer science faculty members and what influences those practices? 5) What incentives or rewards are offered to faculty members who try innovative teaching methods or receive additional training? The motivation for investigating these questions is a general dissatisfaction among students with teaching quality and a desire of faculty members to improve the efficacy of recruitment and retention of students in computer science programs. Over three hundred faculty members participated in an online survey in the Fall of 2008 that addressed the questions stated above. The results of this study helped the author develop and make recommendations to help computer science departments understand faculty attitudes towards teaching and influence their choices of teaching methods.

1 Introduction

This study investigates the attitudes of computer science faculty towards undergraduate education, faculty preparation for teaching, the incentives offered to encourage teaching innovation, the prevalent teaching practices, and the factors that affect them. Understanding the relations between the above variables is of great importance to efforts that aim to improve computer science education. The study is motivated by a perceived general dissatisfaction of computer science undergraduates in their instruction that comes at a time when computer science departments struggle to improve student recruitment and retention. According to a survey by the Computing Research Association (CRA), released in March 2008 the number of undergraduate CS degree enrollments has decreased steadily over the last 10 years in surveyed institutions (Vegso, 2008). For example, it dropped approximately in half between years 2000 and 2007.

In order to comprehend the significance of addressing computer science education specifically, as opposed to borrowing observations from previous education studies in other fields, one needs to understand the additional challenges offered by the nature of computer science as a discipline. Computer science is a rapidly changing field of study. It effectively becomes reinvented every 5-7 years (Tucker, 1996). However, the pedagogical approach has changed very little over the course of time. Unlike mature fields such as physics, chemistry, and humanities, where the relative stability of content makes it possible to amortize development and refine teaching materials over a long period of time, in computer science and similar rapidly-evolving fields, many syllabi are revised nontrivially every year (Wilkens, Kumar, Ramamurthy, Harmeyer, Olan & D'Antonio, 2004). Due to the frequency of these changes, it is difficult for CS instructors to update courses with all of the developments in their area (Wilkens, Kumar, Ramamurthy, Harmeyer, Olan & D'Antonio, 2004).

The rapid changes in computer science theory and technology affect instructional delivery (Tucker, 1996). It might not be a coincidence, therefore, that most computer science instructors (despite familiarity with modern technology) use the simple lecture approach as the exclusive method of teaching

(Prey, 1995; Knight, Prey & Wulf, 1994; Booth, 2001; Wilkens, Kumar, Ramamurthy, Harmeyer, Olan & D'Antonio, 2004). In fact, over 90% of instruction in college and university classrooms relies exclusively on lecture (Hativa, 2000). In 1979, Dunn and Dunn suggested that teachers teach in the manner in which they learned. Given that many computer science faculty have little or no training in teaching (Huang, Turns & Yellin, 2005), this is a fair assumption to help explain the state of teaching practice in computer science courses.

The prevalence of least-effort teaching practices, driven by the rapid pace of computer science innovation, is to be contrasted with the expectations of college students that are changing due to increased use of hands-on, cooperative learning, and other non-lecture teaching styles in high-school classrooms (Wilson, 2004). As more students of the millennial generation (born after 1982) enter college, universities see an increase in the number of students looking for different approaches to learning (Coomes & DeBard, 2004). The increased gap between the expectations and the reality of instruction in CS classrooms further contributes to an unsatisfactory experience for many CS undergraduate students. The above challenges pertaining to computer science motivate a closer look at education in this quickly-evolving field, and hence support the need for this study.

The rest of this executive summary is organized as follows. Section 2 describes the study and its goals. Section 3 presents a discussion of main results of the study organized by research question. Section 4 draws recommendations to computer science faculty regarding teaching in view of this study. Section 5 presents related work. Section 6 concludes the executive summary.

2 A Study of Effective Teaching

The purposes of this study are threefold. The first purpose is to investigate the importance of effective teaching (to faculty members who teach undergraduate computer science), and how it relates to other factors such as faculty attitude towards other job responsibilities, and their perception of the importance of teaching to their institution.

Since the definition of "effective teaching" may be in the eye of the beholder, the second purpose is to investigate what constitutes effective teaching to computer science faculty. Towards that end, questions are addressed regarding the amount of teacher training faculty members received, their theoretical beliefs about effective teaching and their current teaching practices, respectively. The majority of current faculty members were themselves taught using the behaviorist methods such as lecture, or question and answer sessions. Behaviorist methods are largely teacher-oriented in which the instructor delivers the information to the students and then expects specific responses to given stimuli. A current, more popular theory of instruction is constructivism. The constructivist view is largely student-oriented (Felder, 1993). An instructor that uses the constructivist view tends to facilitate the students' construction of knowledge using approaches such as peer instruction, active learning and cooperative groups. The study investigates current teaching practices and the factors that influence them. It is especially interesting to observe whether teaching practices are truly consistent with beliefs. For example, do faculty members who appear to believe in constructivism follow the constructivist practice? It is also interesting to understand the extent to which teacher training translates into practice. For example, do those computer science faculty members who receive more training tend towards practices that are more consistent with recent theories such as constructivism? Yet another interesting issue is to understand factors that affect exploratory practice. For example, are faculty members with tenure more likely to experiment with new teaching methods to improve performance or would they be more likely to stick to what they know best?

Finally, effective teaching cannot be achieved without proper motivation. Hence, the third purpose of the study is to investigate the incentives and rewards that faculty members currently have access to and the ones they desire. If the incentives and rewards are not sufficient, faculty members will not be as inclined to innovative teaching.

To achieve the above three purposes, participants for this study were randomly selected from computer science departments in American colleges and universities. The top seventy schools were selected from all American colleges and universities that have an undergraduate computer science program. An e-mail was sent to faculty meeting the study criteria (i.e., those teaching undergraduate CS courses). They included Instructors (referring to teaching faculty), Assistant Professors, Associate Professors and Full Professors in all areas of computer science. Computer science faculty members included Americans and foreign nationals. The participants were also grouped according to job title and number of years of experience. With a total of 321 faculty members responding to this study it is one of the largest studies that polls computer science faculty.

3 Main Results

The discussion in this section is organized by research question. The section concludes with a general description of additional factors and issues observed in this study. For brevity, a significant amount of tables and data were removed. Only qualitative trends are described. The original quantitative data are found in the researcher's thesis (Abdelzaher, 2008).

3.1 Importance of Teaching: Faculty Views and Influencing Factors

The following observations were uncovered from the survey regarding the importance of teaching to faculty members in computer science.

Importance of teaching depends on the perceived priorities of the institution. The importance of teaching to computer science faculty was shown to be significantly correlated with the perceived importance of teaching to the institution. This is self-evident and expected. Nevertheless, it is contrary to the findings of Brawner et al. (2002) which stated that the importance of teaching to the faculty member was high independently of the perceived importance of teaching to the institution. Upon the promise of anonymity, several faculty members of research institutions in computer science admitted to the researcher that they felt spending too much time on preparing their classes took away from the time they could be using for doing research and earning acknowledgements from the university. This may be related to the fast-paced nature of computer science, where research, service and teaching obligations are harder to meet jointly, which causes faculty to optimize by following institutional priorities more closely.

The perceived teaching priority of the institution is lower than faculty's own. An interesting observation was that faculty generally appeared to believe that teaching was less important to their institution than it was to them personally. The disparity between the personal and (perceived) institutional priority of teaching was seen for all ranks of surveyed faculty, regardless of job title. However, it was most acute for Instructors, as can be seen by comparing. It appears that those faculty members whose primary responsibility was teaching were the most "dissatisfied" with institutional priorities.

The above observation has deep implications as it suggests that computer science faculty members are generally disappointed with the level of importance their institutions attribute to teaching, considering it inferior to their own. In other words, they appear to externalize the "blame", if blame may be cast, attributing it more to their institutions than to themselves. The juxtaposition of this externalization with the correlation between personal and (perceived) institutional priorities, discussed earlier, predicts a motivation problem. Teaching quality may deteriorate if (i) the personal importance of teaching is correlated with perceived institutional priorities, and (ii) the perceived institutional priority of teaching is lower than the faculty's own.

Teaching is negatively impacted by research. Another expected observation is one that relates the priorities of teaching and research. Data showed a significant negative correlation between the priorities of teaching and research. This is reminiscent of a zero sum game where one can only win in one area at the expense of another. It could be symptomatic of the fact that there is no time for faculty to achieve excellence in both research and teaching. One job responsibility wins at the expense of the other. The winner tends to be consistent with institutional priorities. Indeed, in an answer to one of the survey questions, the top reason that faculty gave for not experimenting with new teaching methods was lack of time. This time, the researcher conjectures, is taken up by other responsibilities such as research. Interestingly, while many active researchers are also active in service, a significant positive correlation was in fact found between teaching and service. This may be attributed to the loose definition of service that includes both research-related activities (such as service on conference program committees) and education-related activities (such as undergraduate advising).

Teaching is disconnected from student career goals. Very interestingly, no correlation was found in faculty responses between the importance of teaching and the importance of student placement to the respondents. This lack of correlation implies that faculty in computer science may have a disconnect between effective teaching and the preparation of students for success in their careers. One might expect that effective teaching is not an end goal in itself. Rather it is a means to a goal; the goal being one of preparing students for success as useful contributors to tomorrow's society. This view is not expressed in the data collected from faculty taking the survey. The disconnection was especially prevalent in the answers of Instructors. While Instructors had the highest average rating for the importance of teaching (giving it a full 4.0 out of 4.0 with zero variance), they also reported the lowest mean (of only 2.06 or "somewhat unimportant") for the importance of student placement. This disconnect is perhaps part of the teaching problem in computer science, where teaching may have become increasingly disassociated from the goal of addressing real-world concerns (that make the students of more interest to prospective employers).

Interestingly, aside from teaching faculty, it appears that the disconnect between teaching and placement becomes stronger with seniority of faculty members. The gap is lowest for Assistant Professors, whose mean ranks for the importance of teaching and the importance of student placement were 3.46 and 3.13, respectively (on a 4.0 scale). The difference between the two scores was only 0.33 points, putting both between very important and important. The gap widened for Associate Professors, who ranked teaching higher than Assistant Professors (at 3.49), but ranked student placement lower (at only 3.07). A gap of 0.42 was observed. This gap widened again for Full Professors, who ranked teaching even higher than Associate Professors (at 3.72), but ranked student placement even lower (2.8). A non-trivial gap of 0.92 points was observed. This gap was exceeded only by Instructors who ranked teaching at 4.0 and student placement at 2.06.

The above data shows an important trend in the teaching process. While Assistant Professors appear to regard both teaching and placement as important responsibilities of their profession, this view is held progressively less strongly with seniority. Two conjectures can possibly explain this trend. One potential explanation is that time on the job desensitizes faculty to the importance of student placement. Presumably, Assistant Professors are closer to having been students themselves and hence share the concerns of their students more strongly. Another potential explanation is that more junior faculty come from educational backgrounds that attribute more value to the utilitarian relevance of teaching to society than their senior colleagues who appear to view computer science education, in the spirit of liberal arts, as more of an end goal of independent value itself. A longitudinal study could be of interest to tell which dominant factor is responsible for the observed trend. Either way, the trend demonstrates a current problem. If classes are not expressly linked to student career goals, student satisfaction is negatively affected.

Further evidence suggests that the second possible explanation (that explains the trend by differences in educational background) is not likely to be the right one. If differences in educational backgrounds of junior and senior faculty had such a profound effect on their views regarding the goals of teaching and its relation to student careers, one might expect that junior faculty would also be more likely to adopt recent teaching methods and beliefs (namely, constructivism). The relation between job title and prevalent belief does not support this observation. When asked to agree or disagree with a series of questions designed to test constructivist and behaviorist beliefs, 76.8% of Assistant Professors were found to be predominantly constructivists, while 21.4% were undetermined (too close to call). The breakdown for Associate and Full Professors was almost the same (no statistically significant differences were found between these categories), suggesting that the differences in preparation for junior and senior faculty do not seem to have affected their views about teaching.

Another observation regarding teaching and placement is that student placement was correlated with research and service. Research and Service (especially external service such as serving on editorial boards of journals and on technical program committees of peer-reviewed conferences) are important job priorities of research institutions. One may therefore conclude that faculty at research institutions worry more about student placement than those at teaching institutions. Indeed, this seems to be the graduate school culture of research institutions, and it may be affecting undergraduates as well. Placement of doctoral students in high ranking job locations brings prestige to the advisor.

3.2 Teacher Training

Teacher training is usually left as an optional activity for faculty. There are two important questions that come to mind where optional teacher training is concerned. The first question is whether the optional training classes offered are actually taken advantage of by the faculty. The second question is whether taking advantage of these classes makes a difference in faculty beliefs and practices. This section investigates the first of the two questions. The second question will be addressed later, in the context of investigating faculty beliefs about teaching and faculty teaching practices.

In relation to the first question, the investigation shows that there is “good news” and “bad news”. These are discussed below, respectively.

The “good news”. Data show that teacher training services are indeed taken advantage of by faculty. The amount of teacher training services offered and the amount of teacher training services used are highly correlated. The more types of teacher training services are offered by an institution the more likely faculty members are to use at least one type of teacher training service. Schools were categorized by the number of teacher training services they offered into six categories, offering one, two, three, four, five and six services, respectively. In schools offering only one service, 33% of the faculty reported using it. In schools that offered more services, the percentages of faculty who reported using at least one service were 60% (for schools with two or three services), 69% (for schools with four services), 76% (for schools with five services) and 84% (for schools with six services).

Note that, while offering more services increased the odds that faculty used at least *one*, the overall faculty turnout generally seemed to decline with each additional service offered. This observation is clearly demonstrated from data on the fraction of faculty who used *all* services offered by the school. In schools offering one or two services the percentage of faculty who took them was 33% and 30%, respectively. In schools offering, three, four, five and six services, the percentage dropped abruptly to 7.5%, 8.2%, 6.9% and 4%, respectively. This suggests the need for cost-benefit analysis to determine the right trade-off between having more faculty members try at least one service and having services be generally well-utilized. It also suggests the need to further investigate which types of teacher training services were most popular.

The “bad news”. Data revealed that the offered teacher training services were in part “preaching to the choir.” A significant positive correlation was observed between teacher training services received by faculty members at their current institution and teacher training services received previously elsewhere. In other words, faculty members who chose to attend such services previously, tended to continue to do so. Faculty who opted out previously, also tended to continue to do so. Over half of those who received no prior teacher training, used no teacher training services at their current institution. In contrast, this ratio was less than 30% for those who received prior training. A more encouraging result would have been to see no correlation between attending services at the present institution and attending previous services, meaning that everyone is equally likely to take advantage of offered services. This, unfortunately, was not the case as discussed above. The observation demonstrates a "recruitment" problem (recruiting faculty to take advantage of teaching services in the first place).

3.3 Teaching Beliefs

Based on their answers a survey question designed to test faculty beliefs, faculty members were divided by prevalent belief into constructivists (223), behaviorists (1), and undetermined (59). Ignoring the single behaviorist for the time being, as there was no statistical significance to this one sample, the faculty classification was into constructivists and undetermined. Two key observations were made regarding faculty beliefs.

A faculty with mixed beliefs. The first observation was that computer science faculty did not fall cleanly into constructivists and behaviorists. Their answers, in fact, mixed elements of both theories. The most telling statistic that revealed this issue was the very low *Cronbach alpha* obtained for the reliability of the behaviorist and constructivist scales used, borrowed from Grasha (2002). Reliability of a scale is measured by the degree of correlations between scale items that are supposed to measure the same belief. When respondents have mixed beliefs, the correlation between such items becomes low, resulting in a lower scale reliability measure. Hence, the scale used in this study merely measured the prevalent belief in a mixed belief scenario. Accordingly, a constructivist label, for example, indicated that a person answered more consistently with constructivism than behaviorism. It did not mean that the person followed the constructivist belief to the exclusion of others.

A uniform distribution of belief across faculty categories. The second observation is one regarding the uniformity of the ratio of constructivists to those undermined across faculty categories. A ratio of approximately 4:1 prevailed robustly across different ages, job titles, and self-reported levels of teaching ability. In other words, age, job title, and teaching ability did not correlate significantly with beliefs. The observation is counter-intuitive. One might expect, for example, that Assistant Professors and Full Professors may disagree on beliefs about effective teaching. This expectation was not supported by the data.

Also of interest is to note that the amount of teacher training services received did not correlate with belief. This was especially surprising at first, considering that teacher training services typically have the express goal of altering the beliefs of faculty by promoting those beliefs that are more consistent with effective teaching. In a way, this lack of correlation between teacher training services received and faculty beliefs about teaching may, in principle, be interpreted as a problem with the training services offered at current institutions. Later, this issue shall be revisited, showing that while training did not affect faculty beliefs, it did affect their practices.

The lack of correlation between teacher training and beliefs has another possible explanation. Grasha's question, re-used in our survey to test belief, focused on what faculty believed were the *goals* most consistent with effective teaching. It did not inquire about the *methods* faculty believed were best to achieve such goals. It appears that the population had a clear and consistent idea regarding teaching goals, leaning more on the constructivist side. The real question was whether their practices actually matched these goals. This question is addressed next as faculty practices are investigated together with factors that affect such practices.

3.4 Teaching Practices

In this subsection, a general picture is presented of average teaching obligations of different categories of computer science faculty, followed by observations regarding their teaching practices and the factors that affect them.

Average teaching obligations. The survey data indicated that faculty, with the exception of Instructors, generally taught classes of about 40 students. Instructors' classes were larger with a mean of approximately 57 students. The medians showed a slightly bigger variation, ranging from 30 students for Assistant Professors to 60 for Instructors. Other categories reported medians of either 35 or 40 students. Not surprisingly, Assistant Professors also reported the highest instances of knowing their students by name. The average number of hours spent weekly on class preparation was approximately nine hours for all faculty members except Instructors, who reported spending approximately 15 hours per week. This is consistent with their larger class size. It was interesting to observe that Assistant Professors, who taught the smallest classes, reported the largest median for class preparation time, with the exception of Instructors. All faculty members also reported having an average of just under three office hours per week, with the exception of Instructors, who reported an average closer to four office hours. The medians showed less variation, being three office hours per week for all categories except Assistant Professors, who reported a median of two office hours per week.

Adding up the medians of class preparation, office hours, and undergraduate advising, the total time spent on teaching-related responsibilities outside the classroom was 19 hours for Instructors, 14 hours for Assistant and Full Professors, 13 hours for Associate Professors, and 12 hours for “other” faculty. While this might appear like low numbers, an interesting observation is that faculty whose responsibilities included teaching, research and service spent on teaching alone a substantial fraction of the time spent on teaching by Instructors. This is significant because Instructors presumably had much fewer other job responsibilities.

Teaching methods used in class. The next interesting question is regarding the teaching methods that faculty members used in their classrooms. Overall, roughly half the respondents reported using lecture every class. As far as other regular activities, referring to those performed at least once a week, 43.5% reported weekly use of whole class discussion, 40% reported weekly use of hands-on demonstrations or role-play, 33% reported weekly use of small groups for problem solving every week, and 11% reported use of weekly student-led discussions. In addition, 91% of the faculty reported relating material to real-world context on weekly basis and 88% reported use of a class project. Breaking the data by job title, Associate Professors reported the highest use of the lecture method as well as team projects, whereas Instructors reported the highest use of problem-solving, whole-class discussion, demonstrations, and relation to real-world contexts. Interestingly, faculty who identified themselves as “Other” reported the highest use of student-led discussions.

When correlated with the amount of teacher training received, the lecture method showed a significant negative correlation, whereas student-centered techniques such as problem solving and student-led discussions showed a significant positive correlation. This could be interpreted to mean that teacher training does encourage more effective teaching practices that are more consistent with the beliefs that computer science faulty were shown to have regarding education goals. Indeed, demonstrations, whole class discussions and student lead discussions were all significantly correlated with constructivist beliefs. They were also negatively correlated with use of lecture. Another interpretation might be that those who choose to take teacher training courses are a self-selected subset of faculty who are already more predisposed to the use of constructivist methods in the classroom. In short, while the correlation is significant, it does not necessarily suggest the presence and direction of a cause-and-effect relation.

Interestingly, no significant correlations were found between years of experience and the choice of teaching methods. Also, no significant correlations were found between age and the choice of teaching methods. One may therefore conclude that experience alone does not necessarily correct teaching shortcomings. Training may be a more reliable way to effect behavior change. These results support what Lee (2001), Huang, et al. (2005), and Felder (1993) have noted, that most faculty members teach the way they, themselves, were taught.

Finally, when asked about their willingness to experiment with new teaching methods, faculty without tenure reported being more willing to experiment on average than those with tenure. The difference was statistically significant. The overall average answer was 3.01 on a 4.0 scale, indicating that faculty were generally “somewhat willing” to experiment.

Putting observations from this and the previous research question together, a clear picture emerges regarding faculty beliefs, practices and factors that affect them. Namely, the majority of faculty members in computer science tend to share the constructivist goals (beliefs) of teaching, although not to the exclusion of behaviorist beliefs. They are generally willing to experiment with new teaching methods, but apparently they do not do so. According to survey data, the most significant deterrents to experimentation were the lack of time (expressed by 42% of the faculty) and the belief that current methods work well (expressed by 40% of the faculty). This is consistent with the lack of correlation between years teaching and methods used. If faculty do not mind experimenting but either cannot afford it or find it unnecessary, their preferred teaching methods will not evolve over time. Teacher training was found correlated with the use of student-centered (constructivist) teaching practices. However, there was also a strong correlation between the use of teacher training services at the current institution and their previous use elsewhere. Hence, it may be that the subset of faculty members, who chose to avail themselves of these services, are a self-selected group who are already predisposed to the use of more effective teaching methods. It is therefore not clear whether use of teacher training services *results in* better practices or *is caused by* a predisposition to practice better teaching.

3.5 Faculty Incentives

The final research question investigated what rewards and incentives are offered to faculty members for innovation in teaching and what faculty wish to have as incentives. Many faculty members stated that there were very few rewards offered and as many as 30.4% did not even know of any rewards that their institution offered, which supports Lee's (2001) and Felder's (1993) belief that many faculty members who choose to try innovative teaching methods do so with little or no reward. Overall, approximately half of the respondents reported student evaluations as the used incentive. Teaching grants were second with 26.3% of the faculty reporting having such an option at their institution. Monetary awards were next with 21.8%, and only 4.8% of the faculty reported exemption from other activities as an offered incentive for teaching excellence at their institution. Observe that answers to the incentives question were non-exclusive, meaning that faculty were allowed to state more than one incentive.

In contrast to the distribution of available incentives, the top incentive that faculty cited as desired to encourage teaching excellence was exemption from some of the other responsibilities. As much as 43.3% of the faculty mentioned it as a desired incentive. Assistant Professors were the highest supporters of this reward with 49.2% stating that it was desired. This is consistent with lack of time being the top reported impediment to experimenting with new teaching methods as well as with the negative correlation between teaching and research importance, as discussed earlier.

The next reported incentive in the order of desirability was monetary awards (39.1%). Instructors were the largest supporter of this incentive with 55.6% indicating that they wanted it. Grants were the next incentive (37.8%), also greatly supported by Instructors (66.7%). Student evaluations as an incentive were the least popular overall. The above results can be contrasted with Lee (2001) and Felder (1993). Both of those studies noted that most faculty members who choose alternative methods or attempt innovation in teaching do so with little or no reward. While this appears to be true of the respondents in this study as well, when asked if they would like to be rewarded, grants and monetary awards were close to the top of the list.

The top deterrents to experimentation were lack of time (expressed by 42.6%) and the perception that current methods worked well (expressed by 40.4%). The perception that faculty were better at those methods they had more experience with (31.1%), and the lack of knowledge of alternative methods (28.8%) were the next largest reported deterrent. These were followed by the perception that class subject matter was not well suited for certain delivery methods (19.6%) as well as the perception that faculty were not encouraged to experiment with new teaching methods by their institution (17.4%). Deterrents that were not as widely cited included class size (11.9%), lack of institutional support (14.7%), the perception that alternative methods were not proven good (13.1%), lack of motivation due to tenure status (8%), and the perception of an obligation not to change the current method (2.6%).

4 Limitations and Recommendations

In making recommendations to help computer science departments and their faculty members there are a few limitations that must be considered before one tries to implement the recommendations.

4.1 Limitations

There are some limitations with this study that need to be addressed. The first limitation of note is that this study did not look at gender. Gender could have shown major differences if it had been considered. However, one of the main reasons gender was not looked at is the large discrepancy in numbers between male and female faculty in the field. Even given the large number of possible participants it would have been difficult to get a significant number of female participants to make accurate conclusions based on gender differences.

Another limitation of this study is that it did not look very closely at the effects of a person's country of origin. Due to a desire to refrain from anything that could be socially or politically incorrect, the factors such as cultural differences, language barriers and/or religious implications were not explored. These factors may have an effect on the choice of teaching method. One participant approached the researcher socially and said that a lot of time he resorts to lecture because, his professors in his native country taught like that and no one had problems with learning. However, he also noted that he has begun to use other methods because he realized that his undergraduate students "tune out" during the class (Anonymity Requested, personal communication, September 22, 2007).

Another limitation of this study is that a majority (67%) of the participants were native-born Americans. This can significantly limit the generalization to computer science departments that have a large population of faculty that are foreign nationals or naturalized American citizens. Additionally, 67% of the participants were from large state universities. This could have serious complications, because different size schools tend to emphasize different priorities.

There is also a limitation in the analysis of the data that involves the theoretical constructs of behaviorism and constructivism. The reliability analysis of the scales for behaviorism and constructivism showed a low reliability. Though these scales were borrowed from Grasha (2002), he did not provide a reliability analysis. The fault could have also lain with the design of the question and the subsequent scoring.

4.2 Recommendations

With the above disclaimers, this study suggests ways in which teaching can be improved in undergraduate computer science classes. A more in depth description of ways to accomplish these recommendations are available in the full dissertation. They are described below:

- *Address the perception problem:* The study shows that faculty uniformly believe that teaching is more important to them personally than to their institutions. Improving the perception of importance of teaching to the institution may be beneficial, considering the correlation between the faculty priorities and their perceived institutional priorities.
- *Address the time problem:* The study shows that lack of time is a top deterrent for not keeping up with new solutions for effective classroom teaching.
- *Address the disconnect between teaching and placement:* It appears that faculty increasingly disassociate the importance of teaching from that of student placement. Understanding and possibly reconciling this disconnect may lead to a better alignment of teaching with student goals (which naturally include good placement), and hence increased student satisfaction.

- *Improve recruitment to teacher training services:* Data show that the chances of using these services are significantly correlated with their prior use. In other words, newcomers are apparently harder to recruit than faculty previously exposed to these services. Data also show that while exposure to teaching services does not change faculty goals (beliefs), it is effective at reconciling faculty teaching practices with these goals.
- *Address the incentives disconnect:* According to the answers of surveyed faculty regarding the available and desired incentives, the incentives available at their institutions were not well aligned with those desired. Presumably, offering better-aligned incentives may lead to better results.

5 Related Work

In prior literature, extensive evidence was presented that showed students are expecting more than a passive approach to learning in the undergraduate curriculum (Barker et al., 2005, Baxter Magolda, 1992, DeBard, 2004). DeBard (2004) mentions the distinct difference in the millennial generation of students, who are just beginning to enter post-secondary education. These students have grown accustomed to relying more on their peers and other sources of knowledge rather than on the instructor (DeBard, 2004, Baxter-Magolda, 1992). Meanwhile Baxter-Magolda (1992) points out that at the undergraduate level, men and women have different ways of knowing and thus different ways of learning or processing information. It is because of these higher expectations that students are becoming more dissatisfied with the undergraduate curriculums.

Baxter-Magolda's research is especially pertinent to computer science education because of their desire to recruit and retain women. The Epistemological Reflection Model that resulted from Baxter Magolda's longitudinal study contains four stages; gender-related patterns are reflected in the first three of those stages. The four stages are *absolute knowing, transitional knowing, independent knowing,* and *contextual knowing* (Evans et al., 1998, Baxter Magolda, 1992). Each of the four stages has two different patterns of knowing contained within the stage (Evans et al., 1998). In each of the first three stages of Baxter-Magolda's theory she discusses the differences that tend to occur between the way men and women learn and know. These differences could help computer science faculty understand how to better accommodate the female population of students in their classes.

Tucker (1996) noted that computer science is a rapidly changing field. Unlike more mature sciences faculty members find it harder to develop materials and activities that can be amortized (Felder, 1993). The technology and knowledge surrounding computer science is always evolving and thus much of the material changes from year to year (Lee, 2001). While it is possible that eventually the field will become more stable in its evolution, it is unlikely. New technologies are being invented daily and as such, computer science faculty members need to keep abreast of these changes and pass them on to their students, which make it harder to focus on the content delivery method (Felder, 1993). Unfortunately, this lack of focus on content delivery leads to increased student dissatisfaction. However, researchers began to look at alternative methods in the undergraduate classroom and how they can be used.

Prey (1995) was among the first computer science researchers to look at alternative methods in the undergraduate classroom. During the time that generation x students were entering post-secondary education, she had begun to notice an increasing gap in the curriculum offerings and what was needed or expected by students and future employers. She introduced the idea of cooperative learning in beginning computer science courses, pointing out that in the job field most jobs were done cooperatively rather than individually. To better understand what is meant by cooperative learning Chase and Okie (2000) defined it as a strategy that uses "student peer groups as orchestrated learning environments" (p. 374). Chase and Okie (2000) have noted that group work is an important aspect of computer science education because software development is undertaken in industry by teams of experts, not just an individual. Therefore, it makes sense to allow students to work cooperatively in their classes rather than on an individual basis.

Later, Lee (2001) and McConnell (1996) both discussed the use of active learning in the classroom. Active learning gets students involved in activity rather than sitting passively listening to lecture. Activity can include, but is not limited to, reading, writing, class discussion, responding to thought provoking questions and problem solving (McConnell, 1996). They offered suggestions for incorporating active learning into the classroom. Lee (2001) recognizes that many faculty members may have found that a downside of active learning is that one cannot cover as much content in class, requires too much time for class preparation and seems impossible to use in a large classes. However, active learning can be something as simple as asking students to discuss a question or concept with a neighbor or as complex as physically acting out a concept in the course such as token passing, such as McConnell mentions.

McConnell (1996) offers some suggestions for active learning techniques that can work for many computer science courses, whether they are small or large. He suggests a form of modified lecture that helps alleviate the problem of declining attention spans. A way to do this is to lecture for ten minutes then take a five minute discussion break where students can discuss notes and correct misunderstandings with their neighbors (McConnell, 1996). He also recommends using a think-pair-share technique in which a question is posed, students write an answer for the question then pair up with someone next to them and share their answers. McConnell (1996) suggests after the think-pair-share the instructor could possibly demonstrate some topics, like algorithms, in real-time.

As an example of discussing algorithms in real-time, McConnell suggests that for algorithm tracing; rather than having the instructor tracing the algorithm in a lecture, have the students trace the algorithm in groups (McConnell, 1996). Assign each member of the group a role and have them do the tracing on transparencies which allows for the transparencies to be shared with the rest of the class (McConnell, 1996). McConnell also suggests using demonstration software so that students can interact with the ideas of computer science.

Pollard and Duvall (2006) also felt that by expanding the teaching styles used in the computer science classroom the audience of students that enjoy and succeed in technology related classes would increase. They discuss the use of games and manipulatives in the undergraduate classroom. Pollard and Duvall (2006) integrated the use of games, toys, stories, and play into their regular computer science classes rather than relegating these techniques solely to labs. Although a long range effect of this use of play in the classroom is not yet known, the immediately evident effect was a more fun environment in the classroom. Additionally, they noticed an increased interest in the material and by using manipulatives they noticed that students had an easier time solving a complex proof.

Stamm (2004) suggested that faculty members not limit themselves to just one method but to use multiple methods. Additionally he suggests the use of something jarring to shock the students into awareness. For example he uses the example of a professor that walked to the front of the room and yelled loudly. While this was an unusual experience for the students and got their attention it does not have to be anything quite so loud. The researcher has had personal experience with a professor who enjoyed shocking his students. The first day of classes the researcher was waiting for class to begin when a guy with pink hair, black trench coat and pink shoelaces walked into the room. He then sat cross-legged on the table in the front of the room. All the students slowly quieted and wondered who this character was. It turned out he was the professor, and over the course of the semester he would come in with something different and shocking that professors normally wouldn’t or shouldn’t do. The effect was that students very rarely missed a class and all eagerly awaited the arrival of the professor.

An important aspect of choosing a teaching method for undergraduate courses is that faculty members need to be comfortable with the method they choose. This is why Lee (2001) believes most faulty members choose to fall back on the lecture method. In order to help faculty members choose methods that they are comfortable with, Grasha (2002) includes a series of questionnaires and surveys in his book *Teaching with Style* which helps faculty members determine their conceptual base, and teaching style. Once discovering their teaching style they can look to Grasha’s suggestions for teaching methods that they can use in the classroom.

In order to help computer science faculty members increase student satisfaction and help faculty members with their teaching, the literature presented in chapter two and the discussions presented in this chapter has been used to develop some recommendations.

6 Conclusions

Several conclusions can be made from this study. Namely, faculty members perceive the importance of effective teaching in relation to the importance placed upon teaching by the institution with which they are associated. The importance placed on teaching seems to be negatively impacted by the importance of research. Faculty members who had received teacher training prior to beginning to teach seemed to show a higher likelihood to continue using teacher training services. The beliefs of faculty members tend to reflect the constructivist theory, but often also contain elements of the behaviorist beliefs. Faculty members prevalent belief in not necessarily influenced through the use of teacher training services. Lack of time and knowledge of teaching methodology coupled with lack of comfort with alternative methods are some of the main deterrents to experimenting with different teaching methods in the undergraduate computer science classrooms. This study has also shown that increased teacher training is correlated with more student-oriented teaching methods and less teacher-oriented methods. Finally, the current incentives beyond tenure are not sufficient for faculty members to choose to invest the time and effort to developing new instructional materials for their classrooms. Recommendations were made in response to the above observations.

Given the quantitative analysis, this study suggests that time constraints, lack of incentives and lack of knowledge surrounding teaching methods are major factors affecting the quality of undergraduate education.

References

Abdelzaher, A. (2008). *Faculty Perceptions of Teaching in Undergraduate Computer Science Education,* Ph.D. Thesis, University of Virginia.

Barker, L. J., Gavin-Doxas, K., & Roberts, E. (2005). What Can Computer Science Learn from a Fine Arts Approach to Teaching? *ACM SIGCSE Bulletin, 37*(1), 421-425.

Baxter Magolda, M. B. (1992). *Knowing and Reasoning in College: Gender-Related Patterns in Students' Intellectual Development*. San Francisco: Jossey-Bass Publishers.

Booth, S. (2001). Learning Computer Science and Engineering in Context. *Computer Science Education, 11*(3), 169-188.

Brawner, C. E., Felder, R. M., Allen, R. H., & Brent, R. (2002, June). *How important is Effective Teaching to Engineering Faculty and Administrators?* Paper presented at the American Society for Engineering Education Annual Conference, Montreal, Canada.

Chase, J. D., & Okie, E. G. (2000, March). *Combining Cooperative Learning and Peer Instruction in Introductory Computer Science*. Paper presented at the SIGCSE Conference, Austin, Texas.

Coomes, M. D., & DeBard, R. (Eds.). (2004). *Serving the Millennial Generation:*

New Directions for Student Services (106th ed.). San Francisco: Wiley Subscription Services.

DeBard, R. (2004). Millenials Coming to College. In M. D. Coomes & R. DeBard (Eds.), *New Directions for Student Services: Serving the Millennial Generation* (pp. 33-45). San Francisco: Jossey-Bass.

Evans, N. J., Forney, D. S., & Guido-DiBrito, F. (1998). *Student Development in College: Theory, Research, and Practice*. San Francisco: Jossey-Bass.

Felder, R. M. (1993). Teaching Teachers to Teach: The Case for Mentoring. *Chemical Engineering Education*, *23*(3), 174–193.

Grasha, A. F. (2002). *Teaching With Style: A practical guide to enhancing learning by understanding teaching & learning styles*. Pittsburgh, PA: Alliance Publishers.

Havita, N. (2000). Becoming a better teacher: a case of changing the pedagogical knowledge and beliefs of law professors. *Instructional Science, 28*, 491-523.

Huang, Y., Yelin, J. M. H., & Turn, J. (2005, October). *Future engineering faculty: How do they think about teaching?* Paper presented at the ASEE/IEEE Frontiers in Education Conference, Indianapolis, IN.

Knight, J., Prey, J., & Wulf, W. (1995). Undergraduate computer science education: a new curriculum philosophy & overview. In R. Beck & D. Goelman (Eds.), *Proceedings of the twenty-fifth SIGCSE symposium on Computer science education* (pp. 155-159). Phoenix, AZ: ACM.

Lee, J. A. N. (2001). Teaching and Learning in the 21st Century: The development of "future CS faculty". *SIGCSE Bulletin, 33*(2), 25-30.

McConnell, J. J. (1996, June). *Active learning and its use in Computer Science*. Paper presented at the Integrating Technology into C.S.E, Barcelona, Spain.

Pollard, S., & Duvall, R. C. (2006, March). *Everything I Needed to Know About Teaching I Learned in Kindergarten: Bringing Elementary Education Techniques to Undergraduate Computer Science Classes*. Paper presented at the SIGCSE, Houston, TX.

Prey, J. C. (1995, November). *Cooperative Learning in an Undergraduate Computer Science Curriculum*. Paper presented at the Frontiers in Education Conference, Atlanta, GA.

Stamm, S. (2004). Mixed *Nuts: Atypical Classroom Techniques for Computer Science Courses* (10-4th Ed.). Retrieved February 3, 2007, from Association of Computing Machinery Web site: http://www.acm.org/crossroads/xrds10-4/mixednuts.html

Tucker, A. (1996). Strategic directions in computer science education. *ACM Computing Surveys (CSUR), 28*(4), 836-845.

Vegso, J. (2008). Enrollments and Degree Production at US CS Departments Drop Further in 2006-07. *Computing Research News, 2*(20), 4.

Wilkens, L., Ramamurthy, B., Olan, M., Kumar, A., Harmeyer, K., & D'Antonio, L. (2004). Emerging areas in undergraduate computer science education: panel discussion. *Journal of Computing Sciences in Colleges, 20*, 134-138.

Wilson, M. (2004). Teaching, Learning, and Millennial Students. In M. D. Coomes & R. DeBard (Eds.), *Serving the Millennial Generation* (pp. 59-72). San Francisco: Jossey-Bass.