New CS1 Pedagogies and Curriculum, the Same Success Factors?

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ABSTRACT

New CS1 curricula and pedagogies have resulted in many positive outcomes over the last several years including lower fail rates and increased long-term retention. Given these positive outcomes, the question becomes how much do the traditional factors of prior experience and confidence still play a role in students' performance in and attitudes about these courses? Furthermore, given that increasingly recommended collaborative pedagogies (e.g. pair programming) force students to interact with their peers for a large percentage of their work in the class, how much does the confidence of their peers affect their own attitudes and performance? This paper presents a study investigating these questions. We find that prior experience and confidence still predict success, but only for some students. We also find that student confidence levels have little to no impact on the attitudes and performance of their peers.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education—*Computer science education*

General Terms

Human Factors, Design, Measurement

Keywords

CS1, Peer Instruction, Pair Programming, Confidence, Gender, Prior Experience

1. INTRODUCTION

Over the last fifteen years, the computer science education community has focused much of its attention on developing new CS1 courses to attract a wide range of students and ensure their success. New curricula aim to make computer science accessible and relevant to students, while new pedagogies aim to give students support and increase their depth of learning as well as their comfort and sense of belonging. Fortunately, many of these efforts have been apparently quite successful, leading to reduced fail rates [15, 11], increased retention in the major [13], and better gender balance in the major [1].

Given these successes, our goal was to look deeper into students' experiences in these classes. Beyond high-level statistics such as pass/fail rates and retention, are there remaining issues that deserve continued attention in these state-of-the-art CS1 courses?

A large number of studies have examined a variety of CS1 courses for factors that influence student success (e.g., [18, 4, 2, 22], to name a few). Most of these studies find that prior experience and some variation on student confidence or comfort are significantly correlated with students' performance. To a lesser degree, gender sometimes has also been found to be a factor in students' performance [2]. Many of these previous studies focused on "traditional" CS1 courses (e.g. object-oriented programming in Java with lectures and outside of class programming assignments).

In this work, we examine two major factors that have been shown to influence student performance in a CS1 courses—prior experience and confidence—to determine how they affect a student's own performance in a CS1 course that incorporates many new best practices. We also look for the effect that a student's confidence has on *other* students in the class, given that many of these best practices (e.g., pair programming) force students to interact with each other much more than they would in a course that includes only lectures and individual programming assignments.

In particular, we investigate the following four primary research questions:

1. Does pre-course confidence or prior experience affect performance in the course?
2. Does pre-course confidence or prior experience affect student attitudes about working in peer groups?
3. Do students who are placed into similar pre-course confidence peer groups perform differently than students who are placed in mixed-confidence groups?
4. Do students who are placed into similar pre-course confidence peer groups feel differently about working in peer groups than students who are placed in mixed-confidence groups?

In pursuing answers to the above research questions, we also investigate the relationship between confidence and prior experience, and between these two factors and gender.

We find that both prior experience and confidence significantly predict student performance in the course, but only

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for male students. These factors are also related to students' feelings about working in peer groups. Looking at the effect of peer-group composition, we find in most cases confidence level composition within peer groups has little to no effect on students' attitudes or performance, but that some effect may be present for students with high levels of experience. These results suggest that while new pedagogical designs have improved student outcomes, the playing field due to prior experience is not yet level, and that women and men still experience CS1 differently.

2. BACKGROUND AND RELATED WORK

2.1 Pedagogy Best Practices

The course that we studied uses three practices specifically designed to make CS more relevant and accessible, particularly to women and students of underrepresented groups: a context theme in its curriculum (Media Computation), pair programming during closed labs and out-of-class programming assignments, and peer instruction during class periods. This trio of practices in particular has been shown to significantly reduce fail rates and increase retention [13].

Media computation [15] (MediaComp) is an introduction to computer science and programming in Java that uses media manipulation (digital images and sounds) as a context in which to teach basic programming and CS topics. MediaComp has been shown to have long-term, wide-reaching positive effects, including equal success from men and women in the course, increased retention at several universities, and strong learning outcomes [5].

Pair programming (PP) is a technique in which two students program collaboratively at the same terminal, to produce a single computer program. Many studies have shown the positive effects of PP including increased performance [10], increased retention into subsequent courses and increased student confidence [9]. There are many studies and guidelines about how to best implement PP and how to form successful partnerships. Salleh et al. performed a meta-review on the literature and found that the most important factor in forming pairs is to match students' skill levels [17], a result recently confirmed by Tafliovich et al. [19]

Peer Instruction (PI) has emerged as an effective way to engage students in class [8, 12]. In a PI class, students are assigned preparatory work to do before class, and then held accountable for that work via a short quiz. In class, students answer questions and solve problems in a tightly scripted manner: students first think individually and respond via a classroom response system (typically "clickers," or a low-tech solution like colored index cards) with their individual answer. Next they discuss the question or problem with a pre-assigned peer group of between 2 and 4 students, attempting to come to a shared belief about the correct answer, which they again enter via the classroom response system. Finally, the instructor shows the response distribution from the second vote and leads a class-wide discussion to help dispel any remaining questions or misconceptions. Positive results of PI in CS1 courses include halving fail rates across four different computer science courses [11].

2.2 Experience and Confidence in CS1

In the extensive literature on factors that affect success in CS1, prior experience with CS, programming or math stands out as one of the most reliable factors [6, 22, 2]. Perhaps not surprisingly, Tafliovich et al. find that not only do students with prior experience perform better, but students also believe (correctly) that prior experience is beneficial in an introductory CS course [19].

On the other hand, courses that are designed to mitigate effects of prior experience are often successful. Ventura and Ramamurthy found prior experience did not have a significant effect on performance in a CS1 course that took a design-centric, objects-first approach [21]. Holden and Weeden report that prior experiences differences went away by the end of a specailly designed introductory sequence [7]. Here we investigate whether this effect also holds in a course that has such positive retention outcomes.

Factors related to confidence have also been found to impact students' performance in CS1 courses. Rountree et al. found that intention to get an A was the single biggest factor of success in the CS1 course of the factors they studied [16]. Bergin et al. found that comfort level was one of the three biggest factors (along with pre-university math experience and gender) in predicting success [2]. Other work shows a relationship between prior programming experience and self-efficacy, which in turn leads to higher performance [14].

While many studies have focused on the relationship between gender and success in CS1, a few have also looked at the confidence and prior experience in the context of gender, sometimes with seemingly contradictory results. Taylor and Mounfield found that prior experiences were more broadly beneficial for women students than for men in college CS courses [20]. Bergin and Reilly found that comfort level had a higher correlation with performance for male students than for female students [2]. Meanwhile Berstein found that while comfort was significantly correlated with test performance for female students, for male students other factors were more important [3].

3. METHODOLOGY

We designed a study to investigate the four research questions listed in Section 1. We chose to investigate the effect of confidence within peer groups instead of the effect of prior experience because there is already ample evidence that matching prior experience levels in PP partnerships can be beneficial. We wanted to know: Does the same result hold for confidence levels? And how do confidence levels affect students' experience in their in-class PI groups?

3.1 Study Context

The context for our study was three sections of a CS1 course (course number CSE 8A) in a single term at the University of California, San Diego (UCSD) in the 2012-2013 academic year. This course is an introduction to programming and computer science intended for CS majors with little or no experience with CS and programming; UCSD has a separate introductory stream for majors who enter with significant prior experience (e.g., AP CS).

Each section met for two 75-minute class periods per week and had an associated weekly 50-minute required closed-lab session. Each class section was taught by a different instructor (the authors of this paper), but all used the same curriculum and course materials. Assessments were identical across the sections. A total of 471 students, roughly evenly divided across the three sections, were enrolled after the final drop date and are included in our study.

This course used the MediaComp curriculum, peer in-

struction during the 75-minute class periods, and pair programming during the closed lab sessions and out of class programming assignments. Students were assigned to both their in class PI groups, and their closed lab PP dyads, but they were free to choose their own partners for the weekly out-of-class programming assignments.

3.2 Measuring Experience and Confidence

We gathered students' confidence levels and prior experience levels on the second day of class via the following two questions:

1. How confident are you about your ability to do well in this course?
   (A) Not at all confident (B) Sort of confident/sort of not (C) Totally confident
2. How much CS experience had you had before you started this course?
   (A) Absolutely none (B) A little (C) A fair amount

Students responded to these questions using clickers. These questions were asked among a series of background questions. Students register their clicker devices, so the clicker responses recorded on the instructor's laptop are associated with individual students.

We used such a light-weight instrument because we were most curious about how students' *perceptions* of their confidence and experience might affect their performance and attitudes. In addition, we felt that any recommendations we made would be easiest to implement elsewhere if the process for determining prior experience and confidence was as simple and quick as possible.

3.3 Peer-Group Composition Experiment

To investigate whether or not grouping by confidence would affect students' feelings about and performance in the class, we designed a between-subjects experiment where we controlled the composition their PI groups and PP dyads based on their self-assessed confidence.

Our experiment had two independent variables each with two values: group-work context (PI groups and PP dyads) and group confidence composition (same confidence level vs. mixed confidence level), creating four composition groups: SS (same confidence for both PI and PP), MS (mixed confidence for PI and same confidence for PP), SM, and MM. We evenly distributed the students from the different confidence levels among the groups, but otherwise randomly assigned students to groups.

Initial PI groups were formed at the start second week of the term, and we shuffled the PI groups once during the term. Pair programming dyads were changed weekly.

Although we asked students to rate their confidence in three levels, in our experiment and our analysis we collapsed low- and mid-confidence into one level due to too few students in the lowest level to form same-confidence groupings. In our data analysis we confirmed the validity of this approach; in no case did the low confidence (A) and mid confidence (B) groups ever significantly differ in their performance or attitudes.

Of the 428 students who reported their confidence (see Table 1), eight students were missing data at the time of the composition group assignment. Another 14 students from group MS and 10 students from group MM were inadvertently assigned to wrong-composition groups in the week 6 reshuffling. These 32 students are excluded from analysis based on composition group, but included in analysis of confidence and prior experience.

Group (PI PP)	Low Conf.	High Conf.	Total
SS	57	46	103
SM	55	48	103
MS	54	40	94
MM	50	46	96

Table 1: The number of students in each participant group, divided by confidence level. Abbreviations are described in Section 3.3.

Our analysis includes only students who completed the course, though not necessarily with a passing grade. We believe if anything this might reduce the performance differences we see based on confidence and experience, because it is more likely that low performing students dropped the class rather than high performing students.

Our dependent variables were student attitudes toward their PI and PP experiences and their grades in the class. We measured student attitudes via an end-of-term survey. The complete set of questions pertaining to PI and PP groups is given in Table 5. For the PI segment, we asked students to think only of their first PI group experience. For the PP segment we asked students to think about all of their partners over the term. We used a 7-point level of agreement Likert scale for the PI segment (Very Strongly Disagree through Very Strongly Agree) and a 5-point frequency scale for the PP segment (Almost Never through Almost Always). In total, 406 students responded to the survey, including 349 students who were included in the grouping study (i.e., those included in Table 1).

We measured students' grades on all major course assessment categories, including:

Participation (Par.) and reading quiz (RQ): The number of days a student participated in class using clickers, and the average score on daily short quizzes based on their assigned reading. Par. and RQ each drop three scores.

Programming assignment (PA): The average of the nine programming assignments in the course.

Lab (Lab): The average of their scores on short assessments given at the end of each closed-lab session.

Midterm exam (ME): The average of the students' three highest (out of four) midterm exam grades.

Final exam (FE): The score on the final exam.

Overall (OA): The score that determines the students' letter grade in the course, calculated using the following weighted average formula: $OA = 0.05 * Par + 0.05 * RQ + 0.25 * PA + 0.2 * Lab + 0.2 * ME + 0.25 * FE$.

4. RESULTS

We began by exploring the make up of our class and the relationship between students' confidence and experience. We also broke these categories down by gender. The three sections of the class did not statistically differ in terms of composition of gender, confidence or experience level, nor did they differ on any assessment scores. In our analysis, we aggregate all three sections. Table 2 shows the total number of students in each confidence and experience level. The number in parentheses in each cell indicates the number in each

Conf. \ Exper.	None	Some	A lot	N/R	Total
Low	121 (34)	94 (37)	8 (4)	8 (2)	231 (77)
High	63 (10)	83 (21)	49 (10)	2 (1)	197 (42)
N/R	2 (1)	3 (0)	0 (0)		5 (1)
Total	186 (45)	180 (58)	57 (14)	10 (3)	433 (120)

Table 2: The number of students who reported having each confidence and experience level. Numbers in parentheses give the number of women in each group. "N/R" indicates the number of students who did not respond to the question (but did respond to the other question).

Assess.	Low Conf.	High Conf.	p val.
Par.	0.92	0.93	0.25
RQ	0.99	0.99	0.81
Lab	0.92	0.92	0.75
PA	0.95	0.95	0.61
ME	0.85	0.88	**< 0.01**
FE	0.77	0.79	0.09
OA	0.88	0.89	0.06

Table 3: Scores (out of 1.0) on each assessment by confidence. See Section 3.3 for abbreviations.

Assess.	No Exp.	Some Exp.	A lot Exp.	p val.
Par.	0.93	0.92	0.95	0.16
RQ	0.99	0.99	0.99	0.47
Lab	0.91	0.92	0.95	**< 0.01**
PA	0.95	0.96	0.95	0.45
ME	0.85	0.87	0.92	**< 0.001**
FE	0.75	0.79	0.84	**< 0.001**
OA	0.87	0.89	0.92	**< 0.001**

Table 4: Scores (out of 1.0) on each assessment by prior experience. See Section 3.3 for abbreviations.

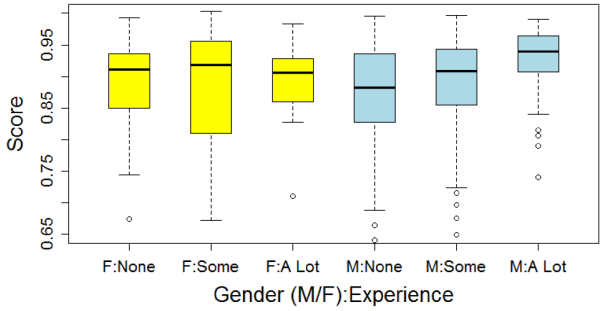

Figure 1: Overall score distribution for males (M) and females (F), with each gender grouped by experience level (None, Some, A Lot). All box graph shows medians, 1^{st} and 3^{rd} quartiles and 1.5*IQR.

category who were women. We found that confidence and experience are only weakly correlated ($r = 0.31, p < 0.001$). There is no significant difference between the prior experience of men and women ($p = 0.35$, Wilcoxon rank sum), but that men on average are significantly more confident than women coming in to the class ($p < 0.01$).

4.1 Confidence & Experience vs. Performance

We examined whether and how confidence and prior experience predict student performance in the course. We found that both confidence and prior experience correlate with higher performance, but only for some groups of students. Tables 3 and 4 show the scores for each assessment by confidence group and by experience level, respectively.

We ran t-tests and ANOVA tests on each grouping, respectively, and found statistically significant differences based on confidence level and prior experience for the midterm exams. We also found significant differences across experience levels for lab quiz scores, the final exam and the overall course average. Particularly for experience levels, the magnitude of these differences was non-trivial. For example, there is a 7 to 9 percentage point spread across experience levels for the exams, which translates to a 5 percentage point spread in the final course average (i.e. more than half a letter grade).

It appears that prior experience and confidence are still success factors even in a CS1 that incorporates many best-practices for retention. However, we find that these performance differences are not universal. Namely, when we split the students by gender, the women show no significant difference in performance by experience level or confidence. The men, on the other hand, show significant differences in performance by experience in their performance on lab quizzes, midterm exams, final exam and overall average (ANOVA, p < 0.01 in all cases). Figure 1 shows the overall course average of men and women, with each gender separated into groups by experience level. For example, in this figure the box labeled "F:Some" shows the distribution of overall average scores for females with some prior experience at the start of the class. A Tukey HSD post-hoc analysis reveals that there is a statistically significant six-point difference separating the overall average of the men with experience and the men with no experience, but no significant difference in performance between the groups of women. Distributions for the final exam and the midterm exam averages look similar, with an even larger spread between the men with a lot of experience and the men with no experience (11 percentage points on the final and 10 on the midterms).

Finally, we divided students by gender and found that for men confidence predicts their midterm exam performance, but for women it does not. A one-way ANOVA on the groups in Figure 2 reveals a significant effect ($p < 0.05$); a post-hoc analysis reveals that the only groups the differ significantly are high confidence men and low confidence men.

4.2 Confidence and Experience vs. Attitudes

We also examined students' responses to our survey questions based on their confidence and experience. We found students' responses differed significantly by confidence, experience or gender for the statements labeled in Table 5, and the direction of the difference is as expected. For example, low confidence and low experience students felt more discouraged after talking to their group members than high confidence and very experienced students.

Finally we looked at the interaction between gender and experience in students' responses to these questions. As we found with students' grades, significant differences by experience given in Table 5 disappear or are greatly reduced

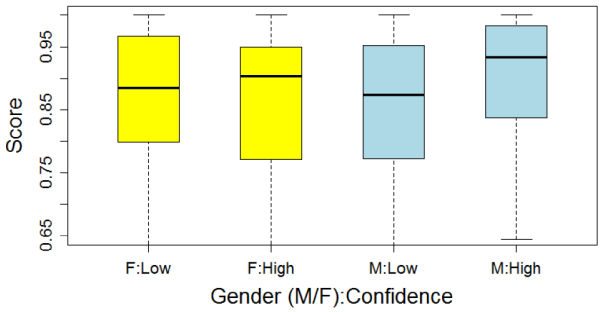

Figure 2: Midterm exam score distribution for men and women, by confidence level.

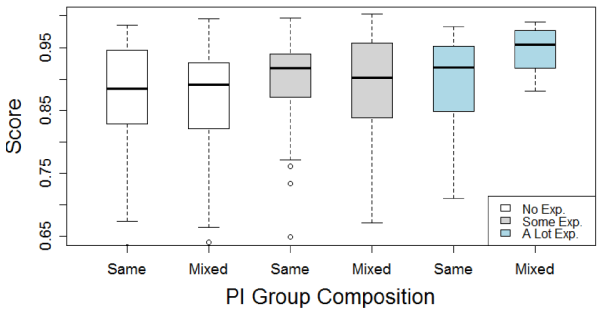

Figure 3: Overall performance by PI grouping (same or mixed) and Experience level.

when we focus only on women, while they are heightened when we focus on the male students.

4.3 Effects of Peer Group Composition

The results of our controlled grouping experiment help us address the third and fourth research questions from Section 1. In other words, how do students' own confidence levels affect others in a highly interactive class?

For the most part, we found that the different combinations of groupings predicted neither their performance in the class nor their attitudes about working with their peer groups. Using ANOVA, we found no significant difference in any of the assessments between the four treatment groups. We also found no significant differences between responses to any of the survey questions between the four treatment groups. Isolating students by gender and by confidence also revealed no significant differences between performance or survey response.

The only hint that peer group composition might affect students came when we divided students by prior experience level. Figure 3 shows the overall course scores for students in mixed confidence peer instruction groups (MS and MM, combined) vs. same confidence PI groups (SS and SM, combined), separated by experience level. Although we did not find significant post-hoc analysis differences between any of the pairs, the large (5 point) difference in median score between the high-experience mixed-confidence-group students and the high-experience same-confidence-group students suggests an area for future exploration.

Finally, we compared survey results across the PI groups. We found no significant differences for any combinations of the factors. It appears that the relative confidence of a student's peers does not affect the way that student feels about working closely with them in class or in the lab.

PI: Rate your level of agreement with the following:
I often felt that my group members knew more than me. (ce)
Talking to my group members often made me discouraged about my level of understanding. (ce)
My group members were respectful of everyone's ideas.
I felt comfortable voicing my thoughts within my group.
I felt I got along well with my fellow group members.
I generally felt that my fellow group members took my ideas and questions seriously.
I participated actively in my group during discussion.
I felt better about my level of understanding after talking to my group.
My group often came to a shared understanding at the end of the discussion.
I often felt that I knew more than my group members. (ceg)
In my group, everyone contributed to a joint discussion.
In general, I enjoyed interacting with my group.

PP: Rate how often each of the following was true:
My partner and I were balanced technically. (ce)
My partner was respectful to me. (g)
Working w/ my partner helped my learning. (cg)
I was stronger technically than my partner. (ce)
I felt comfortable expressing doubts or asking my partner questions.
My partner and I both contributed meaningfully to completing the lab.
I felt good about my understanding at the end of lab. (ce)
My partner was supportive of my learning.
My partner made me feel like I didn't know what I was doing.
I contributed to my partner's learning. (c)
My partner and I didn't really talk much during lab.
I felt lost at the end of lab. (c)
My partner was usually stronger technically than I am. (ce)
I enjoyed working with my partner.

Table 5: End-of-course survey questions. Bold statements were those where students' responses differed by (c)onfidence, (e)xperience, or (g)ender.

5. DISCUSSION AND FUTURE WORK

Overall, the peer-based pedagogical approaches used in this CS1 course appear to be working. The differences reported in Table 5 reflect differences that are not surprising given students' confidence levels and prior experiences. In fact, Table 5 is notable for the questions for which there is *not* a difference based on experience level or confidence. Low confidence and low-experience students feel equally respected and comfortable, and report participating just as actively and enjoying the group work just as much as their high-confidence, high-experience peers.

Differences in performance based on prior experience is consistent with previous findings, indicating that as much as these new pedagogies and curricula have helped with retention, they have not yet leveled the playing field based on prior experience. However, the fact that this difference is notable only for men raises some interesting questions. Is the fact that women report lower confidence levels despite equal levels of prior experience explained by the no-

tion that women have lower confidence levels in general, or do women perhaps have lower-quality prior experiences that are not as beneficial to them in this CS1? Another hypothesis to test in future work is that being in a teacher role is exceptionally beneficial for learning, and perhaps experienced, high-confidence students are more likely to assert themselves in that role. If this is the case, inquiry is needed into how can we encourage experienced, able students with less confidence—in particular women, who are less likely to be confident—to assume that role.

A common anecdote in CS1 tells of a group of lower-confidence, less-experienced students being intimidated by a highly confident student who consistently shouts out irrelevant technical jargon. It seems that this dynamic could play out with dire consequences in student peer groups if low-confidence students were placed with high-confidence students. However, our findings show that this does not seem to be the case, or at least that the anecdote does not play out in a significant way. Our data does not support the use of confidence as a basis for group assignment, since students in any mixture of confidence level seem to have the same attitudes and performance. This is potentially encouraging for faculty who worry about the arduous and meticulous effort required to design group assignments based on demographic criteria, because it suggests that perhaps it is sufficient to allow students to group themselves. Further study is needed on use of other variables such as experience or pretest results, which may yield factors that are valuable for group assignments. In addition, further study is needed to investigate whether the effect of confidence may in fact be important, but only for students who come into the class believing they already have experience.

Finally, because prior experience confers benefits that are not entirely erased by even a pedagogically "state of the art" CS1 classroom, efforts to level the pre-college CS playing field become even more critical. Bridge programs and specially designed introductory sequences that help less experienced students catch up are important, but until access to K-12 CS eduction is equalized, students with no experience will continue to lag behind in college despite our best (and successful) efforts to retain them in a CS major.

6. CONCLUSION

CS1 education has come a long way. As a community we are retaining more students, and a more diverse group of students, than we were 10 years ago. But the work presented here shows that while some problems appear to be solved, some challenges and questions remain. Low-confidence students are more likely to feel frustrated by group work than those with high confidence, and these feelings do not seem to be affected by the confidence levels of those around them. Furthermore, experience is still a factor in (male) students' performance. MediaComp, pair programming and peer instruction are clearly beneficial to students overall; now we must work to refine these techniques (and potentially add others) to make them as beneficial as they can be for each individual student.

7. REFERENCES

[1] C. Alvarado and Z. Dodds. Women in CS: An evaluation of three promising practices. In *Proc. SIGCSE '10*, 2010.

[2] S. Bergin and R. Reilly. Programming: factors that influence success. *SIGCSE Bull.*, 37(1), Feb. 2005.

[3] D. R. Bernstein. Comfort and experience with computing: are they the same for women and men? *SIGCSE Bull.*, 23(3), Sept. 1991.

[4] P. Byrne and G. Lyons. The effect of student attributes on success in programming. *SIGCSE Bull.*, 33(3), June 2001.

[5] M. Guzdial. Exploring hypotheses about media computation. In *Proc. of ICER '13*. ACM, 2013.

[6] D. Hagan and S. Markham. Does it help to have some programming experience before beginning a computing degree program? *SIGCSE Bull.*, 32(3), July 2000.

[7] E. Holden and E. Weeden. The experience factor in early programming education. In *Proc. of CITC5 '04*. ACM, 2004.

[8] E. Mazur. *Peer Instruction: A User's Manual*. Addison-Wesley, 1996.

[9] C. McDowell and et al. Pair programming improves student retention, confidence, and program quality. *Commun. ACM*, 49(8), Aug. 2006.

[10] N. Nagappan and et al. Improving the CS1 experience with pair programming. *SIGCSE Bull.*, 35(1), 2003.

[11] L. Porter, C. Bailey Lee, and B. Simon. Halving fail rates using peer instruction: a study of four computer science courses. In *Proc. of SIGCSE '13*, 2013.

[12] L. Porter and et al. Experience report: a multi-classroom report on the value of peer instruction. In *Proc. of ITiCSE '11*, 2011.

[13] L. Porter and B. Simon. Retaining nearly one-third more majors with a trio of instructional best practices in CS1. In *Proc. of SIGCSE '13*, 2013.

[14] V. Ramalingam, D. LaBelle, and S. Wiedenbeck. Self-efficacy and mental models in learning to program. *SIGCSE Bull.*, 36(3), June 2004.

[15] L. Rich, H. Perry, and M. Guzdial. A CS1 course designed to address interests of women. *SIGCSE Bull.*, 36(1), 2004.

[16] N. Rountree, J. Rountree, and A. Robins. Predictors of success and failure in a CS1 course. *SIGCSE Bull.*, 34(4), Dec. 2002.

[17] N. Salleh, E. Mendes, and J. C. Grundy. Empirical studies of pair programming for CS/SE teaching in higher education: A systematic literature review. *IEEE Trans. on Software Engineering*, 37(4), 2011.

[18] Simon et al. Predictors of success in a first programming course. In *Proc. of ACE '06*. Australian Computer Society, Inc., 2006.

[19] A. Tafliovich, J. Campbell, and A. Petersen. A student perspective on prior experience in CS1. In *Proc. of SIGCSE '13*. ACM, 2013.

[20] H. G. Taylor and L. C. Mounfield. Exploration of the relationship between prior computing experience and gender on success in college computer science. *Journal of Educational Computing Research*, 11(4), 1994.

[21] P. Ventura and B. Ramamurthy. Wanted: CS1 students. no experience required. *SIGCSE Bull.*, 36(1), Mar. 2004.

[22] B. C. Wilson and S. Shrock. Contributing to success in an introductory computer science course: a study of twelve factors. *SIGCSE Bull.*, 33(1), Feb. 2001.