STUDENTS WITH LEARNING DISABILITIES, PAIR PROGRAMMING AND SITUATIONAL MOTIVATION

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Abstract Persons with learning disabilities (LD) are underrepresented in computer science and information technology fields despite the explosion of related career opportunities and interest. In this study, we examine the use of pair programming as a collaborative intervention in with computer programming and compare students with learning disabilities to students who do not have learning disabilities. We concentrate on situational motivation constructs which tap into the desire to meet goals and acquire skills. We find that students with LD and similar students without LD fare the same. For the both groups, three of the four situational motivation subscales increase after the introduction of pair programming. The use of pair programming holds promises as an educational intervention for all students including those with learning disabilities.

Introduction

Advances in computer technology have placed jobs in computer and information systems as the 8th best jobs of the future (Business Insider, 2015). However, given students with learning disabilities (LD) lower rates of college completion (Raue & Lewis, 2011), students with LD disproportionally lack college educations and are underrepresenting in the computing field. Although computing disciplines can provide great job opportunities, all types of students often find computing courses so frustrating that many either give up or perform poorly (Williams & Upchurch, 2001). Students with LD who enroll in computing courses are especially at risk of falling behind and dropping out of introductory programming courses (Burgstahler, 2011; Frazier, Youngstrom, Glutting, & Wakins, 2007; Richman, Rademacher, & Maitland, 2014), even though many of them are interested in learning programming and major in computing.

The use of effective instructional strategies and appropriate accommodations can facilitate learning, boost self-esteem, and provide students with LD with a sense of accomplishment, motivation, and success. Peer-assisted instructional strategies are evidence-based instructional approaches that have been effective for students with LD and other student groups in other subjects (Greenwood, Terry, Utley, Montagna, & Walker, 1993; Harper & Maheady, 2007; Fantuzzo, King & Heller, 1992). Pair programming is an instructional strategy in which two programmers work side-by-side at one computer, collaborating on the same design, algorithm, code, or test, and helping each other solve problems (Williams, 2010). Typically, a programmer acts as the driver who controls the keyboard and mouse, and writes the code. Another programmer acts as the observer or navigator, and is responsible for reviewing the code, and, at the same time, preventing and identifying logical and syntactical errors in the code (Cockburn & Williams, 2000; Estácio & Prikladnicki, 2015). Each programmer takes a turn being the “driver” and the “navigator.” Pair programming has been studied in educational settings, compared to individual programming, and tested for code quality, programming experience, and economic value (Müller, 2006; Choi et al., 2008). Several studies have found that pair programming provided important benefits for students, such as increased student performance and retention in computer science majors (e.g., Lewis, 2011; McDowell, Werner, Bullock, & Fernald, 2006; Watkins & Watkins, 2009).

This study investigated how pair programming impacts situational motivation of students with LD and without LD. Currently, little research has examined the dynamics of pair interaction involving students with LD; less is known about the effectiveness of pair programming for students with LD. It is unclear whether pair programming is beneficial for students with LD, and whether or how it affects their motivation. We asked, “To what extent do students with LD differ from similar non-LD students on situational motivation?”

Theoretical Framework

Two prominent frameworks have guided how we think about human behavior including how students learn and engage with content: Social Cognitive Theory (Bandura, 1986, 1997) and Self-Determination Theory (Deci & Ryan, 1985, 2000). While Social Cognitive Theory concentrates on self-efficacy and resilience, Self-Determination Theory focuses on the role of intrinsic interest and extrinsic rewards on motivating behavior. In this study, we examine the role of pair programming through the lens of Self-Determination Theory as it taps into three basic human needs: performance, well-being, and personal development. Pair programming, the shared task of meeting a goal, inherently guides students through the challenge to master and integrate new skills. Self-Determination Theory also underscores the importance of personal choice. Guay et al. (2000) identified four dimensions that underlie those choices: intrinsic motivation, identified regulation, external regulation, and amotivation. Intrinsic motivation defines those who are engaged for the satisfaction of performing the task (Deci, 1971). Extrinsic motivation refers to behaviors that are conducted for goals that extend beyond the task. This is broken down further to identify externally motivated actions that are engaged to avoid negative consequences (external regulation) and those that are valued and perceived to be chosen by oneself but are still extrinsic (identified regulation). Motivated individuals are neither intrinsically or extrinsically motivated by the task, feel no purpose, and perceive a lack of choice.

Methods and Data Sources

This study is part of a larger, multi-year NSF funded project concerning broadening participation of students with learning disabilities in computer science and information technology. Here we report results from the first year of data collection. The project was reviewed and approved by the university's Institutional Review Board.

Sample

All students in undergraduate introductory computer science and information technology courses at a university in the southeast were asked to complete 10 pair programming exercises. Students with LD self-identified and responded if they were registered with the university's Office of Educational Accessibility (OEA). In addition, the OEA checked the class rosters to double check that we had not missed any students in the class with LD. For the programming exercises, LD students were intentionally paired with non-LD students. A researcher gave instruction on how to perform pair-programming to the entire class twice a semester. All students were asked to complete pre, mid and post surveys that assessed situational motivation among other things. After three semesters, we had data from six undergraduate students (5 male, 1 female) with LD and 93 without LD.

Measures

Situational Motivation Scale (SIMS). We used Guay et al. (2000) Situational Motivation Scale at three time points – pre-pair programming, mid-semester and at the end of the semester. This 16-item scale is broken into four constructs with high internal consistency (Nunnally, 1978): intrinsic motivation (.95), identified regulation (.80), external regulation (.86) and amotivation (.77). The constructs are moderately correlated and the factors unique and invariant across gender. The response categories ranged from 1 (*corresponds not at all*) to 7 (*corresponds exactly*). Example items include, "Because I am doing it for my own good" and "Because I don't have any choice." Scales were constructed by averaging responses; thus, scales scores range from 1 to 7.

Learning Disabilities. A learning disability is "a disorder in one or more basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations, including conditions such as perceptual disabilities, brain injury, dyslexia, or developmental aphasia" (U.S. Department of Education, 2006). To determine students' LD status, we asked students if they have ever been diagnosed with a LD, if they had had an individualized education plan for a LD in K-12, and if they were registered with the Office of Educational Accessibility. We also asked the OEA to examine rosters to determine if there were registered as LD students who did not identify as LD on our survey. We found no discrepancies in student self-reports and the records of the OEA.

Analytic Approach

To mimic random assignment, we matched students with LD with similar students without LD on preliminary scale levels of computing confidence (p=.881), usage (p=.976), interest (p=.789) and attitude toward group work (p=.247) (See Table 1). We used a two-way repeated measures ANOVA to test group differences over time. Although there are only six students in each group (those with and without LD), repeated measures with three data points is an efficient analysis method. The assumptions of sphericity and homogeneity of error variances were not violated. Interactions of the SIMS subscales and the LD condition were universally not significant, so we interpreted main effects.

Results

Intrinsic Motivation. Intrinsic motivation is the concept of engaging in a task for the pure satisfaction or enjoyment of completing the task. While the students with LD appeared to have higher intrinsic motivation scores at the pretest (M_{LD}=3.58, SD=1.641) than similar students without LD ($M_{no\text{-}LD}$=3.00, SD=1.369), the scores shifted by midpoint (M_{LD}=3.67, SD=2.234; $M_{no\text{-}LD}$=4.58, SD=2.149) and posttest (M_{LD}=3.92, SD=1.992; $M_{no\text{-}LD}$=4.25, SD=1.666) as shown in Table 2. Ultimately, there were no differences in LD and matched non-LD students' intrinsic motivation scores ($F_{(1,10)}$=.048, p=.831); see Table 3. However, student scores as a whole rose significantly from Time 1 to Time 2 (after pair programming), and then stayed high in Time 3 (M_1=3.29, M_2=4.13, M_3=4.08, $F_{(2,20)}$=4.557, p=.023).

Identified Regulation. Identified regulation is a form of extrinsic motivation where the student values the task but is not doing it for pure satisfaction. Similar to intrinsic motivation, students with LD appeared to have higher identified regulation scores at the pretest (M_{LD}=4.13, SD=1.385) than matched students without LD ($M_{no\text{-}LD}$=3.29, SD=1.308); however, the scores shifted by midpoint (M_{LD}=3.50, SD=2.455; $M_{no\text{-}LD}$=4.54, SD=2.058) and posttest (M_{LD}=4.21, SD=1.867; $M_{no\text{-}LD}$=4.33, SD=1.045); see Table 2. Ultimately, there were no differences in LD and similar non-LD students' identified regulation scores ($F_{(1,10)}$=.017, p=.900) as shown in Table 3. As a whole, student scores did not significantly change over time ($F_{(2,20)}$=.754, p=.483).

External Regulation. External regulation is a form of extrinsic motivation where students are engaging not only for external reward, but also to avoid negative consequences. Students with LD appeared to have higher external regulation scores at all three time points (pre (M_{LD}=5.33, SD=1.190, $M_{no\text{-}LD}$=4.21, SD=1.926), mid (M_{LD}=6.04, SD=1.239; $M_{no\text{-}LD}$=5.83, SD=.832), post (M_{LD}=5.92, SD=.683; $M_{no\text{-}LD}$=5.38, SD=.440); see Table 2). Ultimately, there were no statistically significant differences in LD and similar non-LD students' external regulation scores ($F_{(1,10)}$=1.697, p=.222) as shown in Table 3. However, student scores as a whole rose significantly from Time 1 to Time 3 (after pair programming) (M_1=4.77, M_2=5.94, M_3=5.65, $F_{(2,20)}$=4.570, p=.023).

Amotivation. Amotivated students are not intrinsically or extrinsically motivated. Students with LD appeared to have higher amotivation scores at all three time points (pre (M_{LD}=3.92, SD=1.320; $M_{no\text{-}LD}$=3.08, SD=1.271), mid (M_{LD}=5.88, SD=1.242; $M_{no\text{-}LD}$=4.58, SD=1.794) and post (M_{LD}=5.79, SD=.781; $M_{no\text{-}LD}$=4.29, SD=1.208)) (See Table 2). Ultimately, there were no statistically significant differences in LD and matched non-LD students' amotivation scores ($F_{(1,10)}$=3.850, p=.078); see Table 3. However, student scores as a whole rose significantly from Time 1 to Time 2 (after pair programming) and then stayed high in Time 3 (M_1=3.50, M_2=5.23, M_3=5.04, $F_{(2,20)}$=12.847, p<.001).

Scholarly Significance

There is a great need to improve the experience in computing courses for students with LD. Authorities in the field of education have indicated that supportive learning environments should be created to promote student active learning, collaboration, and mastery of skills (Johnson & Johnson, 1986; Johnson, Johnson, & Holubec, 2007; Kagan, 1989; Marzano, Pickering, & Pollock, 2001; Slavin, 1994, 2012). In this study, we examined the effect of pair programming on situational motivation constructs for college students with LD and similar students without LD. We found encouraging results. Students with LD were no more or less motivated when compared to a matched sample of students without LD and tracked over time. On average, the entire group saw increases in motivation scores in three of the four constructs over time. Students as a group were more likely to be intrinsically motivated after being exposed to pair programming. They were also more likely to be externally motivated to avoid negative consequences, such as bad grades (external regulation) or lack any motivation (amotivation). These findings indicate that pair programming is an equally effective intervention for students with LD as it is for students who do not have LD. And although we used college students in this study, there is no reason to expect different results in middle and high school settings.

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