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Closed Laboratories with Embedded Instructional Research Design for CS1

Structured Summary of

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Context

Closed laboratories are becoming an increasingly popular approach to teaching introductory CS courses [1], per the recommendations of Denning *et al.* [3] and ACM's Computing Curricula 1991 [4]. Closed labs have several advantages as they facilitate active learning, cooperative learning, and problem-based learning and also provide a more flexible environment that can cater to students of different backgrounds and learning styles. However, as observed in [1], "Considering the prevalence of closed labs and the fact that they have been in place in CS curricula for more than a decade, there is little published evidence assessing their effectiveness."

Research Questions

As part of a comprehensive research agenda examining closed laboratories, we undertook two research studies. The first examined whether cooperative learning groups perform better than direct instruction groups in our closed labs. The second examined whether there were differences in the students' self-efficacy and motivation before and after taking CS1, the first undergraduate computer science course.

Theoretical Background

While direct instruction has been shown to be effective in certain domains, studies have shown *cooperative learning* to be an effective pedagogy for CS, producing significant gains in student achievement [13-15]. Other advantages of cooperative learning are the development of communication and problem solving skills [16]. Most of our students intend to join private industry where collaboration and teamwork are the norm, so collaborative learning in college settings better prepares students for what they will most likely encounter after graduation [17]. Direct instruction at the college level tends to emphasize individual skills, and is often removed from environments encountered in industry [18]. Cooperative learning can help students "become aware of the significance of small group dynamics as a tool for task achievement and success in a team environment" [17]. We relied primarily on the work of Johnson and Johnson [19] to model the implementation of cooperative learning in our CS1 laboratories. We also implemented the five essential elements of cooperative learning [19] into our laboratory design.

Methodology

For our first study, the three laboratory structures were used: cooperative group with structure, *cooperative group without structure*, and *direct instruction*. The difference between the two cooperative groups was the structure of the group: formal versus informal. The cooperative structured group (formal) had defined student roles that alternated each week. The laboratory instructor was responsible for monitoring which student "drives" and which students review. The goal of this format was to develop interdependence among the group members based on the environment (a shared computer) and breaking the tasks into smaller parts with each member responsible for a part. By doing so, the group only functioned if each individual contributed his or her part for the whole group to complete their goal. In the cooperative unstructured group, the roles of the group members were not controlled; the members were responsible for assigning roles. In the second study, we used a pre-post design measuring changes in student self-efficacy and motivation towards computer science.

Findings

In Study 1, both cooperative learning groups performed significantly higher than the direct instruction group ($F(2,66)=6.325$, $p<.05$). In Study 2, in contrast to our hypothesis, we found that students seemed to *decrease* in motivation and self-efficacy. We feel that students bring with them inflated self-efficacy related to CS knowledge and become less motivated to pursue CS as a major after getting a true feel for the field.

Recommendations

Cooperative groups attain higher achievement than the individual direct instruction approach. Our results show that the ACM2001 curriculum paired with the cooperative learning pedagogy not only produces higher achievement but also is consistent with the environment students will find in private industry.

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