Unreal Collaboration: Exploring the Use of Formal Collaborative Learning Strategy in Games Development Coursework

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Abstract

An unpleasant sense of isolation is a common complaint amongst computing students and professionals alike. It is a well-documented cause of attrition throughout the discipline, one to which those from backgrounds already underrepresented in computing are particularly vulnerable. Though no silver bullet exists, collaborative work and learning strategies (such as pair programming) are a well-researched, commonly-practiced means of deterring this sense of isolation. However, studies on the employment of collaborative learning strategies in college-level computing coursework have focused almost exclusively on the use of pair programming methodology in traditional programming courses. A gap exists in the literature with regard to the employment of collaborative learning strategies in non-traditional programming courses, such as those teaching modern game development using visual scripting languages.

This paper will present the findings of a pilot study integrating formal collaborative learning strategy into a game development course taught at a large Midwestern university in the United States; the coding platform employed in the course was the Blueprints Visual Scripting system (Unreal Engine). The learning strategy employed in the course, formal collaborative learning, consists of students working together to jointly achieve specific shared tasks, assignments, and learning objectives over a period of time ranging from 1 class period to several weeks. This paper first discusses the pedagogical and assessment changes this integration entailed. The findings are then presented, with subsequent discussion guided by constructivist learning theory and social interdependence theory.

Background

Computing students and professionals alike commonly complain of an unpleasant sense of isolation. It is a well-documented cause of attrition throughout the discipline, one to which those from backgrounds already underrepresented in computing are particularly vulnerable [1]. Though no silver bullet exists, both collaborative work and learning strategies (such as pair programming) are well-researched, commonly-practiced means of deterring this sense of isolation while simultaneously increasing student sense of inclusivity, sense of self-efficacy, and sense of course-related and discipline-related enjoyment [2-12]. Deutsch writes of collaborative learning:

> Students develop a considerably greater commitment, helpfulness, and caring for each other regardless of differences in ability level, ethnic background, gender, social class, or physical disability. They develop more skill in taking the perspective of others, emotionally as well as cognitively. They develop greater self-esteem and a greater sense of being valued by their classmates. They develop more positive attitudes toward

> learning, school, and their teachers. They usually learn more in the subjects they study by cooperative learning, and they acquire more of the skills and attitudes that are conducive to effective collaboration with others [13].

However, studies on the employment of collaborative learning strategies in college-level computing coursework have focused almost exclusively on the use of pair programming methodology in traditional programming courses. A gap exists in the literature with regard to the employment of collaborative learning strategies in non-traditional programming courses, such as those teaching modern game development using visual scripting languages.

To both address this gap, and to potentially improve our learning environment, we explored the use of formal collaborative learning pedagogy in a college-level game development course during the Fall 2017 academic semester at a large university located in the Midwestern United States. The results of this initial exploration were positive: the course experienced a high completion rate (defined as students completing the course with a grade of "C" or better), high attendance/low absenteeism, low tardiness, and high collegiality with most students successfully matriculating into the next course in the game development course-series. In light of these results, a second exploratory study was performed in a subsequent offering of the same course during the Fall 2018 academic semester, the goal being to extend, and potentially reinforce, the findings of the first. The results of this second exploratory study were also positive. Unfortunately, due to administrative issues, the course format differed between the two offerings (Fall 2017 format: Lecture 0 Lab 2; Fall 2018 format: Lecture 2 Lab 1). Though facets of the course under instructor control remained constant, the format difference makes direct comparison of the results difficult. Instead, we will follow the tenets of *user generalizability* — that is, the reader (i.e., the user of a study) is best able and ultimately responsible for determining which findings apply to their specific situation and learning environment [14] — and present both semesters of study here.

Theoretical foundations

Though there are several theoretical perspectives which have guided research on collaborative learning, two of the most influential ones are constructivist learning perspectives and social interdependence theory.

Constructivist learning perspectives

Constructivism encompasses a number of related learning theories and theoretical perspectives, all of which emphasize that learning is a process of constructing meaning from experiences. Constructivist learning perspectives differ on whether the construction of meaning is primarily personal or social [15]. Personal constructivist perspective is founded on the work of Piaget and frames learning through the perspective of the individual: learning is a personal activity whereby meaning is made by the individual as they progressively adapt to new experiences, incorporating these into their existing understanding of the world around them [16]. In contrast, social constructivist perspective is founded on the work of Vygotsky and frames learning as the construction of knowledge "…when individuals engage socially in talk and activity about shared problems or tasks" [17].

Regardless if the locus of learning is personal, social, or a combination of both, studies have repeatedly shown that individuals learn more effectively when they externalize and articulate their developing knowledge [18]. As Sawyer points out:

> The best learning takes place when learners articulate their unformed and still developing understanding, and continue to articulate it throughout the process of learning. Articulating and learning go hand in hand, in a mutually reinforcing feedback loop. In many cases, learners don't actually learn something until they start to articulate it – in other words, while thinking out loud, they learn more rapidly and deeply than studying quietly [19].

Social interdependence theory

Collaboration occurs when individuals work together to achieve shared goals. A learning goal is a desired state wherein the future the learner can demonstrate competence or mastery of the subject matter. *Collaborative learning* is the leveraging of cooperation in the classroom as an instructional technique; specifically, collaborative learning is the instructional use of small groups of individuals aimed at maximizing their own and each other's learning [20]. Collaborative learning is typically contrasted with *competitive learning* and *individualistic learning*, each defined by a different type of *interdependence* between individuals during the learning process. *Social interdependence*, the foundation of social interdependence theory [21], exists when individuals working toward a goal affect each other. *Positive interdependence* occurs when individuals assist each other toward their respective goals, cooperating with each other; the goal achievement of each individual is thus positively correlated with the goal achievement of others. *Negative interdependence* occurs when individuals discourage and obstruct each other as they work toward their respective goals, competing with each other; the goal achievement of each individual is thus negatively correlated with the goal achievement of others. One example of competitive learning occurs when students are competing with each other for a limited number of A's, B's, C's, etc. in the classroom. *Individualistic learning* occurs when individuals neither assist nor obstruct each other during the learning process; there is no correlation between the goal achievement amongst individuals in the learning environment [22].

For collaboration to be effective, learning or otherwise, five elements are essential [23]. These are:

1. Positive interdependence
2. Individual accountability
3. Promotive interaction
4. Interpersonal skills
5. Group processing

Positive interdependence, discussed above, is the perception by individuals collaborating that their goals can be achieved only together. *Individual accountability* speaks to the need for each individual to be personally responsible for their contributions. Complementing individual accountability is *promotive interaction,* the need for each individual to facilitate the contributions of those with whom they are collaborating. Individuals assist, encourage, praise, and support

each other's efforts. Johnson, Johnson, and Smith describe the role of individual accountability and promotive interaction in a learning context as such:

> Students learn together so that they can subsequently perform higher as individuals. To ensure that each member is strengthened, students are held individually accountable to complete assignments, learning what is being taught, and help other group members do the same [23].

As collaboration requires individuals to simultaneously engage in both task work and teamwork, *interpersonal skills* such as communication, decision-making, and conflict management are essential to success. *Group processing* refers to the continuous examination and improvement of processes individuals employ when collaborating with each other. In essence, group processing seeks to answer the following questions: "what is working for us?", "what is not working for us?", and "how can we make it better?"

Methodology

The study was conducted at a large public R1 university located in the Midwestern United States with approximately 35,000 undergraduate students. The course in which the study was conducted was Game Development I, a 16-week non-introductory development course employing the face-to-face format taken by students primarily having sophomore and junior classification. The coding platform employed in the course was the Blueprints Visual Scripting system (Unreal Engine). The study spanned two offerings of the course, both offerings of which were held in the Fall academic semester (Fall 2017, Fall 2018). Students successfully completing the Game Development I course typically matriculate into Game Develop II immediately after.

Fall 2017

During the initial exploratory study, the course format was Lecture: 0 Lab: 2. That is, there was no stand-alone lecture component to the course. Instead all students in the course met twice per week, each meeting being 110 minutes, in a single large computer lab with a single instructor. There were 27 class meetings total for the semester. To encourage interaction among students, the number of students enrolled in the course was double the number of computers in the laboratory; this forced students to work in pairs. Each week, students were paired randomly with a new partner at the beginning of class; students were never paired with the same partner twice. Beginning the very first week of class, students were responsible for completing individual assignments outside of class as well as group assignments which could only be completed during class and with a partner. Upon completion of each week's group assignment, students completed a questionnaire surveying their experiences with their current partner.

During each laboratory meeting, the instructor would introduce the prescribed group assignment, then support the students as they completed the prescribed assignment. Attendance and tardiness were recorded, as were observations made by the instructor during the course of the laboratory. After each laboratory meeting, the instructor would first reflect, then record their thoughts, impressions, and perspective on the laboratory they had just taught. As the laboratory instructor was also the laboratory instructor for the subsequent course, Game Development II, observations

were continued for the first 4 weeks of the next class to explore the residual impact of the collaborative learning environment on students.

Fall 2018

A now-and-later experimental design was adopted for the Fall 2018 study to allow comparison with the prior Fall 2017 exploratory study, potentially extending our understanding and increasing our confidence in the initial findings. In the now-and-later design, one group serves as the control for a period of time while the other group participates in the intervention. Subsequently, after the effects of the intervention have been tested compared to the control group, the control group then participates in the intervention so that "…all students are eventually part of the treatment group" [24] . The students in the Fall 2018 course offering would work independently for the first 8 weeks of the course, thus serving as a control for the prior course offering, then work collaboratively for the last 8 weeks of the course.

Unfortunately, while factors under instructor control remained constant, the course format and classroom assignment was altered for administrative reasons. The Fall 2018 course offering of Game Development I was Lecture 2 Lab 1: all students in the course met twice per week for lecture, each meeting being 50 minutes, and once per week for laboratory, each laboratory meeting being 110 minutes. In addition, the laboratory component of the course was held in a much smaller computer laboratory, necessitating 6 laboratory sections; however, students were no longer required to share computers, each student now having access to their own computer.

As planned, students in the Fall 2018 course offering completed laboratory assignments independently during the first 8 weeks of course. The last 8 weeks of the course, students completed laboratory assignments in pairs. Once pairing began, each week students were paired randomly with a new partner at the beginning of class; as before, students were never paired with the same partner twice. Students continued to be responsible for completing individual assignments outside of the computer laboratory; however, they now had group assignments which could only be completed during class and with a partner as well. Upon completion of each week's group assignment, students completed a questionnaire surveying their experiences with their current partner.

As in the exploratory study, the instructor would introduce the prescribed group assignment, then support the students as they completed the prescribed assignment during each laboratory. Attendance and tardiness were again recorded, as were observations made by the instructor during the course of the laboratory; and again, after each laboratory meeting, the instructor would first reflect, then record their thoughts, impressions, and perspectives on the laboratory they had just taught. As the laboratory instructor was again also the laboratory instructor for the subsequent course, Game Development II, observations were continued for the first 4 of the next class to explore the residual impact of the collaborative learning environment on students.

Results

Fall 2017

Forty students were enrolled in the Fall 2017 offering of the course, Game Development I, which met 27 times in the computer laboratory throughout the 16 week semester. All forty of the students enrolled completed it with a grade of "C" or better; that is, there was a 100% successful completion rate for this offering of Game Development I. Of these forty students, thirty seven immediately matriculated into the subsequent course, Game Develop II; that is, there was a 92.5% course-series matriculation rate. Throughout the semester, student attendance remained high (depicted in Figure 1) and student tardiness remained low (depicted in Figure 2).

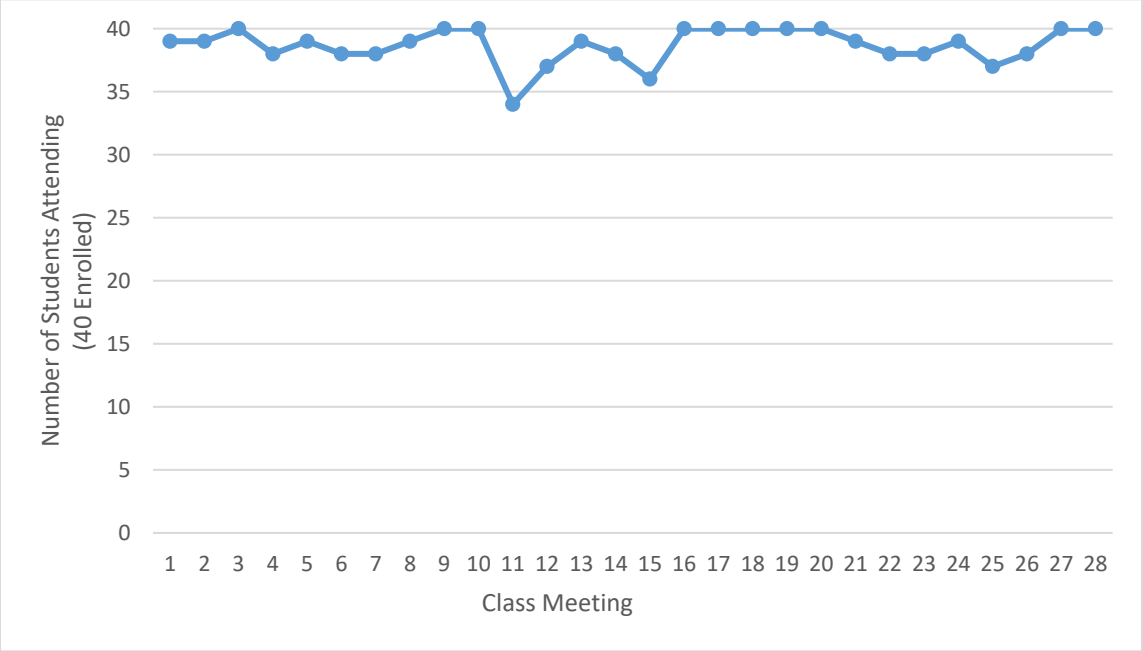

Figure 1. Fall 2017 Student Attendance

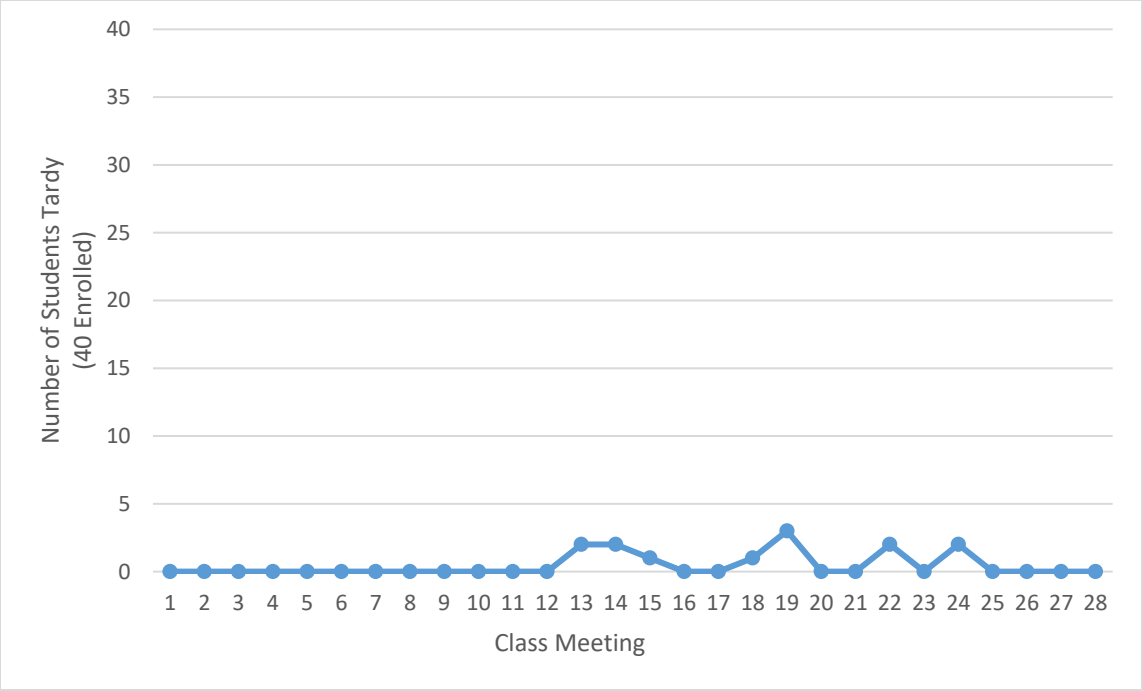

Figure 2. Fall 2017 Student Tardiness

Fall 2018

Ninety three students were enrolled in the Fall 2018 offering of the course which met in the computer laboratory 13 times throughout the 16 week semester. Of the ninety three students enrolled in the course, ninety completed it with a grade of "C" or better; that is, there was a 96.8% successful completion rate for this offering of Game Development I. Two students withdrew from the course, and one student failed the course. Of the ninety who successfully completed the course, eighty two immediately matriculated into the subsequent course, Game Develop II; that is, there was a 91.1% course-series matriculation rate. Throughout the semester, student attendance remained high (depicted in Figure 3) and student tardiness remained low (depicted in Figure 4).

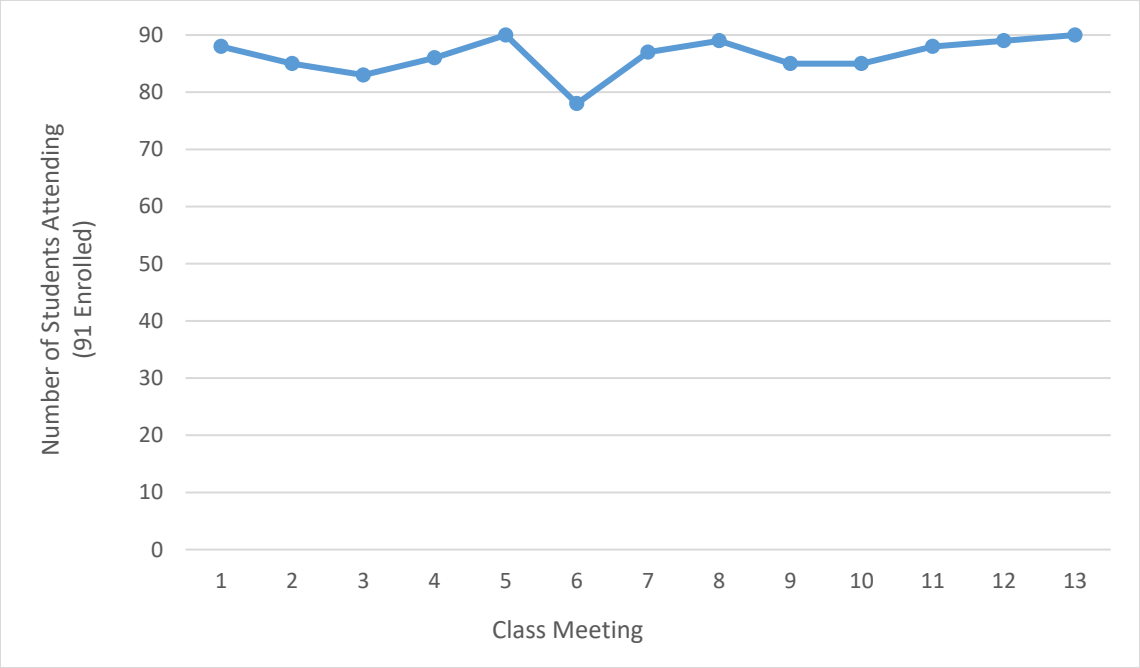

Figure 3: Fall 2018 Student Attendance

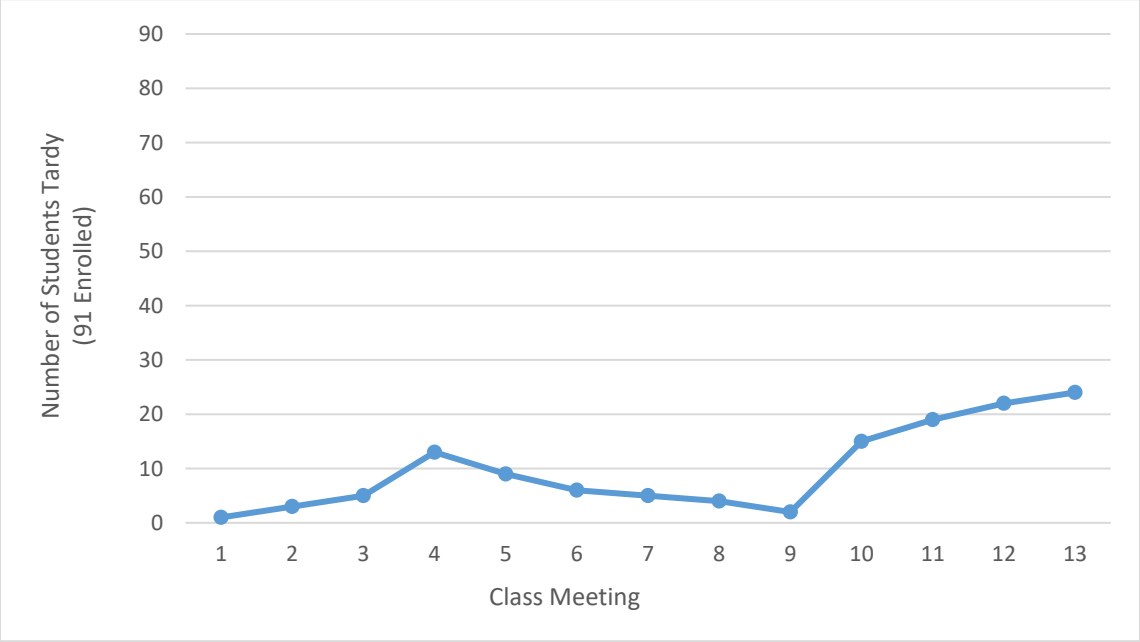

Figure 4: Fall 2018 Student Tardiness

Recall that Fall 2017 computer laboratories would meet twice a week, whereas Fall 2018 laboratories would meet only once a week; hence why Fall 2017 has nearly twice as many data points as Fall 2018. In each case, the semester was 16 weeks in duration, and differences in break days (i.e., October break, Thanksgiving break, etc.) is negligible.

Conclusions and Discussions

In both course offerings, the results of the employment of collaborative learning are encouraging. Attendance in particular appears to improve when collaborative learning is employed. In one instance, Fall 2017, tardiness remained low the entire semester. However, during the entirety of Fall 2018, even when collaborative learning was employed, tardiness remained problematic.

Students in the Fall 2017 course offering had fewer resources (more than twice as many students per instructor; only one computer per pair of students) than the students in the Fall 2018 course offering. In fact, a number of students completing the Fall 2017 course offering expressed displeasure on their end-of-semester course review due to the lack of resources, particularly the lack of 1-on-1 time with the instructor. However, the course instructor's observations made over the course of the semester seem to indicate that this same Fall 2017 course offering, larger in size but which employed collaborative learning the entire semester, was boisterous, joyful, and comparatively happier than the smaller, Fall 2018 offering in which individuals worked independently for the first half of the semester. That being said, end-of-semester evaluations completed by students completing the Fall 2018 offering rarely had these same complaints. In contrast, the Fall 2018 end-of-semester course evaluations often cited 1-on-1 time with the instructor as a boon for the course.

With these results and conclusions in mind, we believe that positive interdependence was successfully achieved in both the Fall 2017 and 2018 course offerings through use of group exercises that could only be completed in the computer laboratory with a partner. Individual accountability was achieved, at least in part, through employment of a weekly questionnaire investigating the contributions, promotive interactions, and interpersonal skills made by each collaborator. We also believe that being amongst friends and classmates (in prior classes as well as current classes) helped to strengthen individual accountability, at least in part. Experience between collaborative partners gained via past and current coursework together also likely contributed to the success of their collaborations, manifesting in strengthened promotive interactions and interpersonal skills.

Finally, the camaraderie that we observed developing over the course of Game Development I appears to continue for at least the first 4 weeks of Game Development II. This phenomena was observed for both offerings of the course, though the level of boisterousness appears to have continued as well (i.e., students in the Spring 2018 Game Development II offering are more gregarious while students in the Spring 2019 offering are friendly yet reserved).

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