Inspiring Collaborative Benefits: An Interaction Between a Virtual and a Physical Group Learning Infrastructure

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ABSTRACT
The physical environments are often limited for fostering and enriching creativity and collaborative benefits, especially in the educational context. In general, students have limited opportunities to experience peer-to-peer and group collaborative learning. Gaining knowledge, understanding and group interaction skills from a collaborative learning experience in a classroom are often rare. This paper introduces how a virtual environment can be combined with a physical environment to achieve collaborative benefits. We observed an online homework submission system that facilitated this collaborative process. Although this is only one example of one class, these observed collaborative benefits and the way that the virtual and physical environments combine to produce them could be useful for other courses where collaborative skills are necessary or desired.

Categories and Subject Descriptors
K.3.1 [**Computer Uses in Education**]: Collaborative learning and Computer assisted instruction

General Terms
Design, Human Factors

Keywords
Education Technology, Scalable Game Design, Online Homework Submission System, Experience Report

1. INTRODUCTION
The debate over the advantages of the virtual versus the physical in respect to classroom environment continues to boil over into most university courses. Increasingly, popular print and online forums have been suggesting that professors and teachers were replaceable with online educational materials [1], and ipod lectures [2]. Some academics have even suggested that technological advances that give free access to educational materials and award credentials for scholastic achievement make most university systems obsolete [1]. Although there may come a time when the university system has outlived its usefulness, it is not today. Universities still develop meaningful educational systems that transcend and use current technology. Although universities offer many online courses, the majority of courses are offered in the traditional physical classroom environment. So what value or advantage can be gained from continuing to instruct students in a face-to-face, physical classroom when technology promises a better learning experience?

Peer learning, pair programming, circle discussions and open classrooms are examples of innovative instruction methods based on the traditional physical classroom. These types of teaching methods provide students with a rich learning experience that is worth the possible inconvenience of having to attend a physical classroom during a specified time [3,4]. However, the authors referenced in the first paragraph would undoubtedly support the technological or virtual environment over the physical. And traditional college professors would support the physical environment. But, collaborative benefits can be derived from both a physical classroom as well as a virtual environment. So both the virtual and the physical teaching environments could enhance the collaborative learning experience in a single course of instruction, when both forms complement each other. Is it possible to combine both types of environment without sacrificing the advantages that each one offers? Could there be an approach to gaining collaborative benefits where the interaction of the virtual and the physical combine in such a way that the result is more than the sum of these environmental parts?

2. COLLABORATIVE BENEFITS
For this study, the collaboration process is characterized by frequent face-to-face interaction, a shared task or problem, and a common end-result or solution that is better than any of the group members could have designed alone. Collaboration has the advantage of helping students to consider the process of thinking, as well as uncovering problems that an individual student may not regard as important [5]. Another one of the collaborative benefits of group work centers on economic advantages, for the students as well as hiring companies. A student with collaborative skills is positively positioned to begin contributing to the work-team soon after accepting employment But, the most obvious benefit is the

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wealth of innovative ideas that a workgroup can create through the communicative interaction process.

2.1 The Physical Environment

As many professors know, there are roadblocks to the successful implementation of collaboration, especially in the classroom. Participants must set aside time for multiple meetings, as well as individually working on project pieces. In most instances, meetings require the physical presence of all group members. The participants must also be able to work cooperatively with each other, interpersonally, and receive criticism of their work, in a positive manner. Peer criticism can be upsetting for many students, making them less cooperative toward the group goal. Students are also apprehensive about risking their grade point average on classmates' skills. Even though the outcome of a successful collaboration should result in a product or solution that is substantially better than the sum of all the individual member contributions, most students try to avoid group work by dividing up the project tasks, and hoping that once the pieces are combined, the end result will resemble the stated requirement. Since this is not really collaboration, and the end result is often less than what the students could do individually, the students are unable to experience the benefits of collaborative work.

So the collaborative process yields increased benefits, but is plagued by interpersonal and logistical difficulties. Several journal articles suggest that allowing classtime for group meetings is an effective way to help foster the collaborative process [3,4,6,7]. Eastman and Swift suggest the use of discussion boards and chat rooms to augment face-to-face or physical interaction, for solving the time constraints that usually plague classroom groups [8]. And Hulbert recommended using group role functions to improve classroom collaborative work [9]. Over fifteen years of research offer many strategies for improving student collaboration. All these methods usually build on the basic idea that collaborative benefits can be gained through a physical environment [8,9,10,11]. Often, this physical nature of the collaborative process represents more difficulties than benefits.

2.2 The Virtual Environment

Could a virtual environment offer an alternative? Current research suggests that the virtual environment can be used for the implementation and/or the support of collaborative processes. Online networks such as Second Life have several collaborative groups. Second Life has a large distributed learning network, and it has become a popular destination for members of local work groups. These work groups within Second Life demonstrate increased productivity, which has been facilitated by meeting availability [12,13]. Eliminating the physical space requirement has served to enhance member availability for meetings.

Another virtual environment used for collaborative functions is the business-to-business network. This network facilitates the interaction and sharing of information throughout its entire network by using a web-based interface. Although this association has been in existence for many years, the use of this technology has enabled the member businesses to share their information more accurately and quickly [14]. The use of virtual environments for collaboration is not new. However, facilitating collaborative benefits within a physical environment, through a virtual environment could be considered relatively unique. The Scalable Game Design Arcade (SGDA) could complement the physical classroom in just such a way.

3. TOWARD THE COLLABORATIVE: A VIRTUAL SUBMISSION SYSTEM

The Scalable Game Design Arcade (SGDA) is an educational online infrastructure that facilitates a more user-friendly homework submission format for the Educational Game Programming class. Through SGDA, students can play classmates' games and download game programming. They are also able to directly submit their games to SGDA, rate other student's games, and in share feedback on each other's work. Without any time lag, students can benefit from each other's game ideas before the submission deadline.

3.1 Game Programming Class Evolution

Even though the games generated by the Educational Game Programming class would be considered gamelets or small games, for the purposes of this paper the words, "game" and "gamelet" are used interchangeably.

The Educational Game Programming Class was designed to teach students theoretical and practical knowledge for creating educational games using AgentSheets software. Students usually build one gamelet per week for the first 8 weeks and one individual final project for the rest of the semester. The first four games are directly dictated to the class, in other words, all students must make their own version of the same game. For the next 4 weeks, "Gamelet Madness", students must create an educational gamelet of their own each week. During Gamelet Madness, the students are not allowed to create a gamelet related to their previous work. Including the final project students are expected to submit a total of 9 gamelets for the semester. So, thirty-two students created more than 300 games in a single semester.

In general, the physical dimension of this course has remained constant over the last several semesters. However, the homework submission format, a virtual environment, has changed and evolved in response to other research and student feedback [15].

Individual students were required to submit weekly homework in the form of games. This weekly submission cycle created a need for a suitable submission system that would accommodate the large amount of data generated by the games. Besides creating a new submission format with enough space, an added idea was to facilitate interaction between the students and their games in the same manner that occurred in middle school computer clubs. This idea originated from observing the collaborative benefits that middle school students gained from this educational system [15].

Since 2003, when the Educational Game Programming class was first taught for modeling educational game design, several homework submission infrastructures have been used. The first approach was an individual email submission format. Each student emailed his or her games to the grader by the designated deadline. Although this is a typical approach for submitting assignments in university classes, submitting games in this manner had some unique challenges. The university email system would not send attachments larger than a stated quota, so students had more difficulties attaching the games to the emails. And several students complained that their submitted games never arrived to the grader, as there was no submission confirmation. Another concern for the professors was the lack of collaborative interaction that was observed in the middle school computer club [15].

The second approach used the Gallery Organizer Repository of Projects (GORP, 2006) infrastructure. GORP brought partial success. Although GORP improved the students' ability to play and download each other's games, the time lag between submission and posting by the grader, prevented students from gaining any ideas from each other's games until after the due date. As a result of this system, students could not give or receive feedback of any kind. In the GORP infrastructure peer-to-peer and peer-to-artifact interaction was still limited and students could not use any creative ideas gained from other students' games to improve their own. In short, GORP was not user friendly enough to facilitate the type of interaction needed to motivate the students to improve their own games before submission.

So in the spring semester of 2009, the Scalable Game Design Arcade (SGDA) was introduced to the Educational Game Programming class. The study of Repenning et al indicates that an open classroom environment, based on a middle school computer club, can encourage and motivate students to collaborate and share their work [15]. A unique collaborative infrastructure was needed to interest them in collaborative efforts.

3.2 Scalable Game Design Arcade

SGDA consists of three parts; the game submission page, the game index page, and an individual game page.

Students submit their games with a game title, a game description, a game applet, game codes, and a screen dump on the game submission page. The game description is brief and informative with an emphasis on the game instructions and goal. Since the applet is based in Java, the students' games can be played directly from SGDA. And once the game submission is successfully completed, all students' games are ready to be played. This virtual version of the "instant replay" is an added incentive for the students. All the uploaded games are displayed on a game index page, which is open to the public. This is the first thing you see when you access SGDA.

The game index page contains a table with meta- information for each game including the game title, screen dump, author name, game summary/playing instructions, and submission time. The screen dump and instructions give the potential player a preview of how the game looks, making game selection easy. The column for the game author's name is a direct link to their status page. Here, visitors can download and rate the game, and add their feedback. Also on the index page, unlike GORP and the email submission format, a game author can confirm their game submission by checking the table on the game index page.

Figure 1 Game Submission Page

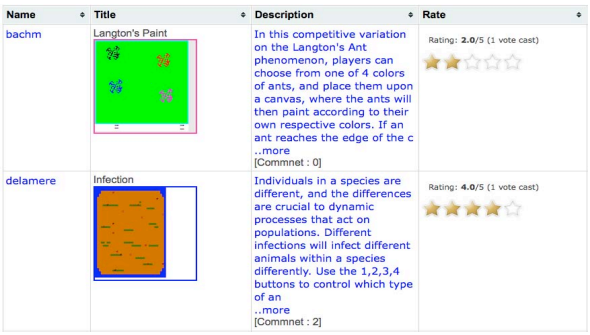

Figure 2 Game Index Page

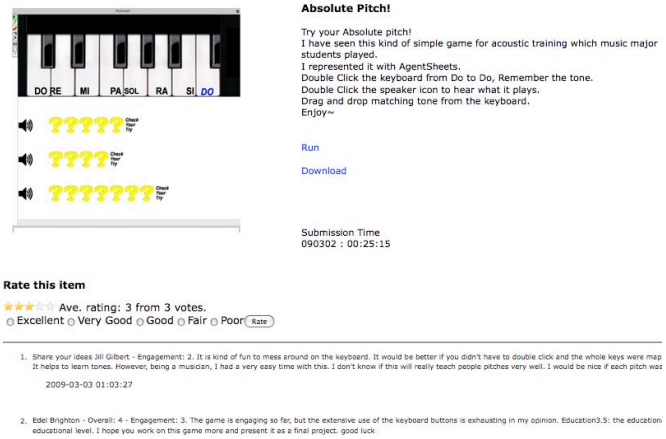

Figure 3 Individual Game Page

Another feature specific to SGDA is the students' ability to download each other's programming immediately after submission (no time lag). Although this may appear like copying, so far this has not been the case. In fact, the students' use of this feature allowed them to use programming behavior from one game to create a completely unique game design of their own. In other words, we found that students tended to update or modify their own games based on the other students' games on SGDA.

3.3 SGDA Benefits

The games submitted to the SGDA by the 2009 Educational Game Programming class, demonstrated several pattern relationships between the individual games over the course of the semester. One example was the increased use of a pre-designed background image. AgentSheets allows users to customize their game backgrounds with image files. Although, no instruction for this feature was given in class, interestingly, the population of students who used this feature grew over time. At the beginning of the semester, there were only two people who loaded images as their background, but after 8 weeks twenty-six of the thirty-two students in class incorporated background images in their games. Students learned how to load image files for their game background without any formal instruction or discussion in class. And all these backgrounds were unique and specific to the original games of the different authors.

The increase of this feature without any formal instruction could indicate a collaborative process. This indication is further supported by some of the students' survey comments. These comments point toward the students' use of the SGDA's download feature, as well as the comment feature to critique their

own game and/or improve it. These comments were collected in answer to the third question in an end of semester survey [15], "Have you ever changed your game after playing a classmate's version of the game? If so why and what changes did you make? Please be specific".

- Seeing some people's innovative approaches to "level design" or scoring, made me adapt some of my own games differently than I otherwise might have.
- Yes, for example, my lemonade sale game was inspired by the "prisoner's dilemma" trade game.
- Yes, sometimes. I've got some ideas from playing classmates' games. i.e if someone made a simple money calculation game, I might want to take that idea with different themes. Also, some UI aspects can be acquired from playing other games because other people think in different way from how I do.
- I like to see how creative everyone is being. I am interested in finding new game play concepts as well as control methods. I am also looking to be entertained.
- When I play a game created by someone else, I look for interesting ideas and design, and hope to find some inspiration for my own games. I also hope to be entertained for a while by their game.

These comments indicate that the students were inspired by each other's programming to make enhancements and design changes that they would not have thought of without SGDA. Consequently, a higher level of game quality was realized. The possible collaborative benefits, referred to above, take place on SGDA between the students and the games.

Innovation is a requirement for technological advancement, and recent research suggests that creativity and innovation is more prevalent in collaborative and open environments. Consequently, it has become expected of universities to provide some kind of instruction in these skills. However, university instructors often struggle to find ways to incorporate collaboration and creativity into their coursework [5]. So, observing this indication of collaborative benefits in the Educational Game Programming class was surprising. And since this was the first class to use SGDA we surmised that these collaborative benefits could be the result of SGDA use. Most of the games created, represented more than any one of the individual students would have produced without access to SGDA, but each game is also one student's creation. Consequently, SGDA, a virtual environment, could be seen as a contributing factor to the quality improvement as well as the increased creativity of the students' own game designs. This indicates a tendency towards a collaborative benefit (artifact/peer inspiration to higher quality level) experienced by the students through their use of SGDA. Another question from the end of semester survey [15], asked, "Has a classmate's game you played for a previous week's assignment inspired your current week's assignment? If so explain".

- I downloaded a classmate's version to see how he/she implemented transportation. I didn't use their coding exactly, but it did give me enough sense to implement it myself.
- Yes, there were a few times where I was trying to implement a feature in my game that someone else had done a different way that I liked more. For example, I struggled to find a way to keep score and display that score in a neat way. However, one of my classmates had a good way of doing it. I kept my original idea and design, but I changed my game to keep score the way they did.
- Yes, my Digital Logic gamelet was inspired by one of my classmates who had done a digital logic gamelet the week before. I got the idea of using logic circuits from their game and molded my own game out of it.
- I saw one student use sokoban to teach a new concept, and was amazed at how fun it became. The next week I used sokoban to teach a new concept.
- Yes, after seeing another student's robot game I wanted to try to make my own interpretation of there idea.
- I have used a classmate's game to overcome some technical problems in my own games.
- Yes, better approach to gaming and simulations.

These comments are representative of the general way that most of the students in the Educational Game Programming class used the arcade to inspire and improve their own games. Although the students in all of the previous Educational Game Programming classes were expected to participate in peer-to-peer learning experiences in class, the extent to which the 2009 class were motivated from each other's games on SGDA was significantly increased. We also observed increased in-class interaction than in previous classes. Since traditionally most collaborative benefits are derived from a physical environment, only augmented through computer-mediated-communication, the observation of collaborative effects in a physical environment possibly being facilitated through a virtual environment (SGDA) deserved out attention.

Although the observations from the Educational Game Programming class indicate that a virtual environment can support the collaborative benefit of idea sharing and generation, this is only a first indication. The structure of the homework submission infrastructure for this class, evolving over multiple semesters, has produced collaborative benefits for its students, evidenced by student comments in an end-of-class survey and the prevalence of the specific feature of the background image on many students' games. These collaborative benefits, peer/artifact inspiration and improved process problem-solving skills, had not occurred in previous classes, so this infrastructure could have been instrumental in these collaborative occurrences. This web infrastructure added a virtual dimension to the physical classroom. By this unique interaction of virtual and physical venues, the students' games exhibited some interesting collaborative tendencies. The success of this infrastructure to facilitate even some of the benefits of collaboration is remarkable in that most collaborative experiences are originated from a physical environment and only enhanced by the virtual. Clearly SGDA has had some interesting results due to the interaction of the virtual and physical learning environment.

4. DISCUSSION

The "instant replay" feature of SGDA contributed to the collaborative benefits experienced by the students of this specific class. By using SGDA to submit homework, students were able to

view and play other students' games. Within the context of the Educational Game Programming class, when students would play games on SGDA, they would automatically look for features that would improve their own game. So the students could learn to use/play the new feature before learning how to program and submit it. The knowledge of how a specific feature is programmed then becomes linked to the knowledge of all the unique ways that the programming behavior can be used, not just the specific game it was originally used in. The game feature and programming knowledge are linked together into the students' intellectual schemata, which can then be more easily accessed at a later date. In essence, using a contextual learning infrastructure such as the Scalable Game Design Arcade provides students with the opportunity to make new intellectual/technical knowledge and skills their own, while creating a new game. The students profit from the collaborative benefits of learning new ways of thinking and increasing their knowledge and skills through sharing their ideas.

Some students gained new ideas for game features, as well as ideas for entirely new games just through this person-to-artifact interaction. The creativity and the generation of multiple game ideas, increased by collaborative interaction with SGDA, seem to be an impossible idea. This unique benefit of collaborative process fostered by a virtual infrastructure into a physical classroom environment is surprising. However, we readily admit that further research is necessary to clarify whether SGDA can truly enhance the collaborative and inspirational experience for students without the physical and interpersonal disadvantages of traditional collaborative environment. Perhaps this unique collaborative interaction is dissimilar enough from collaboration that it should be designated differently. But this is a question for later debate.

Obviously this is only one system used in one classroom. And although this study is only an indication of the possibilities that could be available for the use of this interactive technology, further research should explore whether these collaborative benefits are unique to this particular class, or if this type of technological collaboration/inspiration can be attained using similar systems in other course curriculum. Clearly, dissimilar types of curriculum would probably need a different mix of virtual and physical environments to achieve collaborative benefits, but these possibilities are worth investigating in future research. Further research is particularly vital as studies of the virtual/physical interaction learning environment, like this one, to date have been inconclusive. According to Barbara and Yukie et al [16] when conducting a meta-analysis of articles on these types of learning environments, "… the results varied to such an extent that only tentative, rather than firm, conclusions can be drawn about promising online learning practices." Consequently, interactive learning environments offer opportunities for teachers to expand their curriculum and the traditional ways of learning, so collaborative benefits can be realized by more students.

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