Exploring Collaborative Learning Methods for Multiplayer Educational Games in Low Resource Environments

Heather Underwood[1], Sunil Garg[1], Clint Tseng[1], Leah Findlater[2], Richard Anderson[1], Joyojeet Pal[2]

{ [1]Computer Science & Engineering, [2]The Information School } University of Washington

{ hmu2@cs, skgarg@cs, cxlt@cs, leahkf@u, anderson@cs, joyojeet@u } .washington.edu

ABSTRACT

To facilitate learning in low-resource environments where children must share a single computer, we developed MultiLearn, an educational, single-display groupware system. Prior work has suggested that computer games can be effective for fostering learning [5] and qualitatively supports the benefit of collaboration over competition in a multiple-input, shared display environment [2]. Through MultiLearn we have begun to explore the benefits of introducing collaboration into an innately competitive setting (computer games) for learning environments in low-resource areas. We present preliminary findings from a study of 192 students in Bangalore, India, exploring the impact of differing degrees of collaboration and competition within MultiLearn.

Author Keywords

Single display groupware, shared computing, multiple input, education, collaboration, competition, developing regions

ACM Classification Keywords

H.5.2 Information interfaces and presentation (e.g. HCI): User Interfaces.

General Terms

Experimentation, Design, Human Factors, Performance

INTRODUCTION

Computer use in low-resource learning environments typically consists of a many-to-one scenario, in which multiple children share a single computer. Sharing a keyboard and mouse often results in dominance patterns and unequal access to educational material [1]. To address this issue, researchers have introduced systems to allow for multiple users to use the same computer through multiple mice [1] building on past work on single display groupware [3]. Taking this work further, we present MultiLearn (Figure 1), an educational classroom computer game using multiple 10-key numeric keypads and a split-screen design.

The MultiLearn software consists of several games that drill students on math, spelling, and other subjects. It uses adaptive questioning based on individual student performance and includes a teacher platform for curriculum development. The durable, portable, low-cost hardware provides a feasible solution for developing regions. Prior research suggests that both collaboration and competition impact children's

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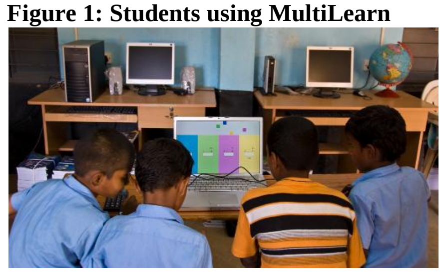
Figure 1: Students using MultiLearn



engagement and learning gain, and that ways of combining the impacts of both are an important step ahead in the multiple input learning space [2]. Consequently, a critical design component in MultiLearn is the incorporation of collaboration in the interactions between individual users. We have designed several game configurations that enforce individual versus team scoring and individual versus team input.

To understand the impact the different modes have on students' performance and collaboration outcomes, we conducted a study with 192 grade school students in Bangalore, India. We present here preliminary findings comparing a purely competitive mode and a combination mode of collaboration and competition. Our findings illustrate that a mix of competition and collaboration results in improved performance and evidence of students working together to solve a problem. In examining important mechanics in the actual collaborative process, we find that issues such as the need to challenge stronger children, domination by aggressive children, and gender issues in mixed groups further support the fundamental premise of this research—that an appropriate balance between competition and collaboration is likely to offer the most in learning gains in multiple input scenarios.

STUDY METHODOLOGY

We conducted a study to compare the impact of different collaborative setups, varying individual versus team play, as well as individual versus shared keypads. The goal was to explore how to effectively introduce collaboration into a competitive educational game in the context of multiple input devices. In this paper, we focus on two game modes that best illustrate the difference in performance between a strictly competitive mode and a mode that physically promotes collaboration:

No Collaboration (M4) Each student was given a keypad and played a purely competitive game against three other players.

Physical Collaboration (M2) Pairs of students shared a keypad and completed questions together, competing against other pairs.

In total, 192 students in the 4th, 5th, and 6th standards from five separate schools participated, including 89 boys and 103 girls. Students participated in groups of four, randomly chosen from the same grade level. They were first given a brief explanation of MultiLearn in their local language. To familiarize themselves with the game and the keypad, all groups began with M4. The order of presentation for the remaining three conditions was randomly generated for each group. During each condition, students were presented with a series of math questions and given as much time as necessary for one individual or one team to complete their question set. When an individual or team won, the game stopped and the students moved to the next round. The software automatically logged accuracy (percentage of questions answered correctly) and completion time for each keypad. In addition, we manually recorded observed collaboration metrics, including *working together* and *passing the keypad*. For example, instances of asking each other questions, using each other's fingers to count numbers over 10, or rechecking each other's work to make sure the answer is correct, were all recorded as instances of working together. When all modes were completed, students were asked a series of qualitative questions about their experience with the game and if they preferred working as a team or independently. Finally, the teachers were asked to rate the students based on their typical class performance in order to analyze collaborative and dominance behaviors in strong and weak academic students.

PRELIMINARY FINDINGS

Our findings represent 48 groups of students. Table 1 shows a direct comparison of accuracy, completion time, and instances of working together. Since M4 was presented before M2 for all groups, the improved accuracy and completion times are partly attributable to a general learning effect. However, several other factors also played a role and warrant further study.

The higher accuracy rate for the collaborative mode can be largely attributed to teammate confirmation of answers. This affirmation fosters confidence and pride, which in turn results in more correct answers among smart children who are initially timid. Students may be more comfortable with answering and submitting a question when they have the support and affirmation of a teammate, thus reducing the time spent questioning their input. Although spontaneous collaboration occurred in M4 (e.g. one student teaching another how to play), the instances of working together indicate that when collaboration is enforced through sharing of a keypad (M2), students are more likely to work together to solve the problem. The improved performance in M2, however, did not always correspond to increased collaboration: in some cases the lower completion time may have been caused by one strong, dominant student using the keypad exclusively.

Table 1: Performance and collaboration metrics by game mode (*N* = 48 groups).

Game Mode	Accuracy		Completion Time (seconds)		Instances of Working Together	
	M	*SD*	*M*	*SD*	*M*	*SD*
M4	0.60	0.3	26.3	10.8	21.9	7.5
M2	0.66	0.3	18.2	12.2	39.0	21.4

Our qualitative observations of students' interactions also indicate increased collaboration in M2. In one instance, a student who ignored another student in the competitive mode, collaborated very well with that student in M2 by using that student's fingers to count and double-checking answers. The previously ignored student also enjoyed the benefit of the teamwork, and was much more involved in the M2 mode. The feedback we received from the students (excluding answers like "I liked all the games" or "I don't know") was also overwhelmingly in favor of the team game (Table 2). Students were more comfortable with using the system together and enjoyed the game more when they could play as a team. These findings, in addition to teacher feedback that collaboration is preferred in order to minimize hurt feelings and low confidence among individuals, provide clear motivation for future work on the causes and effects of collaboration in low-resource learning environments.

Table 2: Students' preferred game mode. (*N*=101 students)

Game Type	Boys' Favorite	Girls' Favorite
M4	11	21
M2	34	35

CONCLUSIONS AND FUTURE WORK

Recent work in the developing world, including MultiLearn, has stressed the need for further research in collaborative learning environments. Our results suggest that collaboration paired with competition can have significant impact on performance results, indicating that competition can still play a motivating role in learning techniques when collaboration is present. We plan to conduct an extensive learning evaluation with pre- and post-tests to determine the value of MultiLearn as a learning tool. We also plan to evaluate more specifically how collaboration and performance metrics are affected by the number of input devices used, gender, skill level, and competition in educational environments.

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