Students that Benefit from Educational 3D Games

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***Abstract*—We describe an educational 3D game called Rashi Game. Rashi Game features a fully functional, and open-ended, 3D environment for students backed by a domain-independent inquiry-learning tutor. We present pilot work that directly compares Rashi's classic 2D interface against the 3D game environment. We compare both the student's work within the system, as well as their reported sense of presence. Specifically, we notice some interesting patterns in student behavior within the game, dependent on the student's preference for games, and argue that there may be potential for modeling when and how to present a student with an educational game based on simple factors such as whether or not the student plays games regularly, or based on student affect (e.g. a lack of motivation).**

Keywords-Serious Games; Intelligent Tutoring; Inquiry Learning

I. INTRODUCTION

The video game industry is often considered to be a small and relatively insignificant niche in today's consumer and entertainment world. More recent data shows that video games are a significant (and growing) part of our daily lives. In fact, sixty-five percent of American households play computer or video games and sixty-three percent of parents believe games are a positive part of their children's lives. [1] These statistics are evidence that video games are becoming a part of American culture that cannot be ignored. Games may provide an opportunity to contribute to an important element of education in which most modern pedagogical strategies fail...motivation and engagement.

The primary goal of our project is to build an intelligent educational game and demonstrate the advantages of having students participate in such an activity. We have adapted the Rashi Intelligent Tutoring System, converting it into a 3D interactive game that teaches inquiry skills through differential diagnosis. Thus, we have access to two functionally equivalent interfaces for the Rashi Tutoring System. This paper describes our pilot efforts in directly comparing the effects of these two interfaces.

II. PREVIOUS WORK

Many researchers are beginning to look into the promise of using video games as an educational tool. Some have taken the approach of simply applying an interesting graphical interface onto an otherwise easily recognizable educational exercise. The game Mily's World [2] teaches math by engaging kids in a world inhabited by a girl named Mily. The player solves math problems, and by doing so earns various rewards (e.g. a new puppy).

Other games have students learn through realistic simulation. Crystal Island allows students to take on the role of a member of a science team doing research on a mostly uninhabited island [4]. It features a fully 3D interface and environment in which players explore, and collect important information by meeting and conversing with other agents. Another game allows students assume the role of a journalist who needs to edit French documents [3].

Another simulation game is UrbanSim [5], motivated by military personnel who must learn unique leadership skills. UrbanSim simulates hostile situations in foreign countries for military leaders. Studies show that UrbanSim increases student 'presence' relative to an equivalent 2D interface [6].

Unfortunately, there is a lack of conclusive evidence regarding what works well, when, and for whom. However, there is evidence that students are more engaged, motivated, and feel more 'involved' in the experience [3][6].

III. THE RASHI GAME

Rashi is an inquiry learning system that provides an environment in which students are involved in authentic learning experiences by exploring realistic problems. The system provides case descriptions for students to investigate, along with information about how to approach each problem [7]. Rashi is domain independent; however, this work focuses primarily on the *Human Biology* domain.

Rashi provides students with a 2-dimensional interface with which to explore. The student is presented with a sick patient, and is asked to diagnose the individual by developing hypotheses, and then collecting data from several sources to construct an argument. The 2-dimensional interface features more than just text and buttons, but rather provides interactive images, and other visuals to increase the authenticity of the experience.

In addition to the interface above, a 3-dimensional (and functionally equivalent) Rashi game was designed and provides a new interface to the system. The game was developed using a 3D gaming engine called IRRLicht [8].

Rashi game is thus designed as a small 3D hospital in which the student takes on the role of a doctor who must diagnose a patient. The student's character begins just outside the lobby and may walk in and speak with the receptionist to receive the case description. The hospital contains the lobby (from which the case description and "coach" can be accessed), a laboratory, and a patient room.

Figure 1: Students can perform lab tests in the virtual laboratory.

Icons exist throughout the environment that appear as 'X's on the floor, signaling to the player that an interaction can be accessed. Students can access specific tools, depending on their location in the environment. Therefore, students must move their character to different rooms to access different tools.

Lastly, students can utilize advice from Rashi's coaching module by speaking with a character in the game introduced as Robert, a fellow doctor who also works at the hospital. By speaking with Robert, students can obtain advice regarding their hypotheses.

IV. Pilot Study

Rashi game was evaluated using a pilot study in the classroom. The study was aimed at evaluating the differences of teaching with 2D versus 3D tools.

Five students used Rashi in the classroom during the 2010 summer session at the University of Massachusetts, Amherst. The students were all college level, and were enrolled in an introductory biology course.

The students began the session by using the standard 2D Rashi client for the first case. This work lasted approximately 1.5 hours, and most students were confident in their diagnosis of the patient by the end of this time period. Afterwards, the students began a different case (i.e. a new patient to diagnose) but instead, explored the case using the Rashi game. This session, due to time constraints, only lasted around 20 minutes.

Students ended their session by comparing the interfaces both quantitatively and qualitatively. Students filled out a questionnaire asking them to directly compare the two interfaces. We asked students to compare the interfaces as a learning tool, and as an exercise in learning. In addition, we invited students to evaluate the *presence* that the game invoked, adopting questionnaire items from Lombard and Ditton [9]. Qualitatively, we discussed with students the degree to which they have experience with and/or enjoy games (i.e. enjoys games, is open to games, or dislikes games). During these discussions, we also invited students to discuss their opinions and feelings regarding the two interfaces.

V. Results

The results of this pilot study reveal some potentially interesting and promising avenues for further research. Firstly, students did approximately the same amount of work using both interfaces, averaging *1.8* and *1.6* hypotheses per case for the 2D and 3D environments respectively. This is despite the significant difference in time spent on each respective interface. When we look at the amount of work performed, split by user's preferences for games, we see that game players and non-game players tended to perform more work in the game. People who were open to games tended to do much less work in the 3D case.

	All Users	***Game Players***	***Open to Games***	***Dislike Games***
Num Hypos 2D	*1.8*	*1.0*	*2.5*	*1.5*
Num Hypos 3D	*1.6*	***3.0***	*0.5*	***2.0***

Table 1: Number of average hypotheses per student for each Rashi interface.

Users reported that the 3D game was slightly more engaging than the 2D Rashi, but also reported that they felt slightly less motivated. We see that users who don't play but are open to games are more engaged, while the other two groups are less engaged. Interestingly, when it comes to motivation, the users correlate perfectly with their preference for games. Game players are the most motivated, while those who dislike games are the least motivated. Table 2 summarizes these results.

Students did report that they felt the 3D Rashi game was a slightly better learning tool. However, all the measures of *presence* that were tested achieved lower scores for 2D Rashi, with the one exception that students reported the game as being more 'involving'.

	All Users	***Game Players***	***Open to Games***	***Dislike Games***
Engagement	***2.6***	2.0	**3.5**	2.0
Motivation	***2.2***	**3.0**	2.5	1.5

Table 2: Reported scores of engagement and motivation for the 3D Rashi Game.

Thus, the tests for presence yielded, in general, greater scores for the 2D interface. However, the 3D game was deemed more involving. Also, students who dislike games found the game to be more mentally immersive than the 2D game. In fact, the level of mental immersion was inversely related to how much a student enjoyed playing games. This is contrary to our intuition.

	All Users	Game Players	Open to Games	Dislike Games
Mentally immersed?				
2D:	7.4	9.0	7.5	**6.5**
3D:	7.2	**6.0**	**6.5**	**8.5**
Involving?				
2D:	**6.8**	8.0	**7**	6.0
3D:	**7.0**	8.0	**7.5**	6.0

Table 3: Student reports of immersion and involvement

Qualitatively, our discussions with the various students yielded some interesting patterns. Overall, the most optimistic responses game from the two students who described themselves as being open to games. These students talked to us about how interesting the experience was. They thought it was "cool" and relatively inspiring. They still pointed out that the 2D interface seemed more well developed. These users interestingly pointed out that the 3D environment was lacking in content. This perception is interesting as the two interfaces were in fact equivalent in content. The one game playing student had relatively positive feelings towards the game, but felt less engaged because the game did not live up to his expectations. Truly, our 3D game is not of commercial quality. Lastly, the two non-game playing students felt that the 3D experience was "creepy". They reported that they didn't receive any enjoyment out of it, and merely wanted to get their work done efficiently (in the 2D environment). This was a sentiment that was somewhat shared among all participants.

VI. Discussion and Future Work

It is unclear that any students benefited from the 3D game activity. However, we do see that students that play games and students that dislike games both performed more work within the system. It is likely that students who enjoy games will be more motivated with a game based activity. However, students found our game to be less engaging, and thus design efforts that balance fun and play in a way that is competitive with commercial games are needed.

It is becoming clear that games, although not a dominant teaching strategy, have the potential to be effective when given to correct students at correct times. We need to move toward a model of student affect that intelligently observes students as they learn and can opportunistically offer gaming as an activity in appropriate situations.

Future work on this effort will focus firstly on obtaining larger and more significant student sample sizes. This is necessary for observing whether or not our pilot observations generalize. Once this data is collected, we can begin to model how student affect is influenced by a variety of simple factors (including age, gender, and whether or not the student plays games regularly). The end result will hopefully be an intelligent agent that can decide to present games to a student based on their state of affect.

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References

[1] *"Video Game Industry Statistics"* From GrabStats.com 2008. Accessed on Nov. 14, 2009. http://www.grabstats.com/statcategorymain.asp?StatCatID=13

[2] Rai, D.; Heffernan, N.; Gobert, J.; Beck, J. "*Mily's World: Math game involving authentic activities in visual cover story"*. In Proceedings of the Workshop on Intelligent Educational Games 2009. Brighton, England.

[3] Hallinen, N.; Walker, E.; Wylie, R.; Ogan, A.; Jones, C. "*I Was Playing When I Learned: A Narrative Game for French Aspectual Distinctions"*. In Proceedings of the Workshop on Intelligent Educational Games 2009. Brighton, England.

[4] Rowe, J.; Bradford, W.; Mott, B.; McQuiqqan, S.; Robison, J.; Lee, S.; Lester, J. "*Crystal Island: A Narrative-Centered Learning Environment for Eighth Grade Microbiology"*. In Proceedings of the Workshop on Intelligent Educational Games 2009. Brighton, England.

[5] McAlinden, R.; Gordon, A.S. Lane, H.C,; Pynadath, D. "*UrbanSim: A Game-based Simulation for Counterinsurgency and Stability-focused Operations"*. In Proceedings of the Workshop on Intelligent Educational Games 2009. Brighton, England.

[6] Lane, H.C., Hays, M.J., Auerbach, D., & Core, M.G.. *"Investigating the relationship between presence and learning in a serious game."* In J. Kay & V. Aleven (Eds.), Proceedings of the10th International Conference on Intelligent Tutoring Systems, Springer.

[7] Dragon, T., Woolf, B. P., Marshall, D. and T. Murray. *"Coaching within a domain independent inquiry environment."* International Conference on Intelligent Tutoring Systems. Jhongli, Taiwan, (2006)

[8] "*IRRLicht: Lightning Fast Realtime 3D Engine"* http://irrlicht.sourceforge.net/ Last Accessed on: 9/26/2010

[9] Lombard, M., Ditton, T.: *"At the Heart of It All: The Concept of Presence."* Journal of Computer-Mediated Communication 3 (1997)