

Motivational Impacts of a Game-Based Intelligent Tutoring System

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Abstract

iSTART is an intelligent tutoring system (ITS) designed to improve students' reading comprehension. Previous studies have indicated that iSTART is successful; however, these studies have also indicated that students benefit most from long-term interactions that can become tedious and boring. A new game-based version of the system has been developed, called iSTART-ME (motivationally enhanced). Initial results from a usability study with iSTART-ME indicate that this system increases engagement and decreases boredom over time.

Introduction

Intelligent Tutoring Systems (ITSs) have been producing consistent learning gains for decades. However, a common problem with these systems is maintaining student engagement. This is particularly problematic for ITSs that require long-term tutorial interactions that span across days, weeks, or even months. Student interest within these types of tutoring systems often wanes over time due to the repetitive nature of practice tasks.

One previously successful solution to improve engagement has been to incorporate game-like components into educational environments (Dickey, 2005). Several systems have taken this route and begun to create combinations of Intelligent Tutoring and Games (McNamara, Jackson, & Graesser, 2010). One example of this endeavor is the new Interactive Strategy Training for Active Reading and Thinking (iSTART) tutor which has been recently adapted into a game-based environment where students can practice strategies, earn points, advance through levels, purchase rewards, create a personalized avatar, and play educational mini-games.

iSTART

iSTART is an ITS designed to improve students' reading comprehension by teaching self-explanation in combination with effective reading strategies. iSTART introduces students to the concept of self-explanation and provides

instruction on how to use reading comprehension strategies to improve self-explanations and comprehension. The development of iSTART was based on previous research with a successful human intervention called SERT (McNamara, 2004; O'Reilly, Taylor, & McNamara, 2006). Students who have been provided with iSTART have shown significant improvement in reading comprehension, comparable to the performance within SERT (Magliano, Todaro, Millis, Wiemer-Hastings, Kim, & McNamara, 2005). iSTART training is separated into three distinct modules that instantiate the pedagogical principle of modeling-scaffolding-fading: introduction, demonstration, and practice, respectively.

During the introduction module, three animated agents (one teacher and two students) hold a vicarious classroom-like dialogue. This dialogue presents the concept of self-explanation and the associated iSTART reading strategies (comprehension monitoring, prediction, paraphrasing, elaboration, and bridging). These agents interact with one another to provide descriptions, examples, and counter examples of each reading strategy. After each strategy discussion, formative assessments are presented that gauge the student's current level of understanding for that strategy.

After all strategies have been introduced and modeled, the system transitions into the demonstration module. The demonstration module utilizes two animated agents (one teacher, one student) that apply the self-explanation strategies to an example text. During this scaffolding phase the user is asked to analyze and identify the various strategies being used by the student agent. The dialogue and feedback between the animated agents foreshadows the interaction that the users will have during the practice module.

The practice module in iSTART allows students an opportunity to apply the self-explanation strategies within their own self-explanations. This module fades out most direct instruction and uses formative feedback to guide the interaction. Merlin (the teacher agent during demonstration) serves as the self-explanation coach by providing feedback for every student-generated self-explanation and prompting them to use the newly acquired strategies. The main purpose of this module is to provide students with an opportunity to apply the strategies to new texts and to integrate knowledge from different sources in order to understand a challenging text.

Within iSTART there are two types of practice modules. The first practice module is situated within the core context of iSTART (initial 2 hour training) and includes two texts. The second practice module is a form of extended interaction, and it operates in the exact same manner as the original practice module. During this extended practice phase, a teacher can assign specific texts for students to read. These texts are either already in the system or can be added to the system on short notice. Because of the need to incorporate various texts, the iSTART feedback algorithm has been designed to adapt to new texts, and its performance has been comparable to that of humans (Jackson, Guess, McNamara, 2010). The extended practice module is designed to provide a long-term learning environment that can span weeks or months. Research on iSTART has shown that the extended practice is effective at increasing students' performance over time (Jackson, Boonthum, McNamara, 2010). However, one unfortunate side effect of this long-term interaction is that students often become disengaged and uninterested in using the system (Bell & McNamara, 2007).

iSTART-ME

To combat the problem of disengagement over time, the extended practice module of iSTART has been situated within a game-based environment called iSTART-ME (motivationally enhanced). This game-based environment builds upon the existing iSTART system. The iSTART-ME system and design rationale has been more extensively described in other papers, so it is only briefly described here (Jackson, Boonthum, & McNamara, 2009, Jackson, Dempsey, & McNamara, 2010).

The main thrust of the iSTART-ME project is to implement and assess game-based principles and features that are expected to support effective learning, increase motivation, and sustain engagement throughout a long-term interaction within an established ITS. Previous research has indicated that increasing self-efficacy, interest, engagement, and self-regulation should positively impact learning (Alexander, Murphy, Woods, Duhon, & Parker, 1997; Bandura, 2000, Pajares, 1996; Pintrich, 2000; Zimmerman & Schunk, 2001). The iSTART-ME project attempts to manipulate these motivational constructs via game-based features that map onto one of the following five categories: feedback, incentives, task difficulty, control, and environment. These categories are discussed in detail in (McNamara, Jackson, & Graesser, 2010).

The previous version of iSTART automatically progressed students from one text to another with no intervening actions. The new version of iSTART-ME is controlled through a selection menu (see Figure 1 for screenshot). This selection menu provides students opportunities to interact with new texts, earn points, advance through levels, purchase rewards, personalize a character, and play educational mini-games (designed to use the same strategies as in practice).



Figure 1. Screenshot of iSTART-ME selection menu.

Within iSTART-ME, students can earn points as they interact with texts and provide their own self-explanations (top of Figure 1). Each time that a student submits a self-explanation, it is assessed by the iSTART algorithm and points are awarded based on a scoring rubric. The rubric has been designed to reward consistently good performance. So, students earn more points if they repeatedly provide good self-explanations on consecutive turns, but earn fewer points if they fluctuate between good and poor performance. In addition to providing a form of feedback, earning points within iSTART-ME serves two main purposes: advancing through levels and purchasing rewards.

As students accumulate more points, they advance through a series of levels. Each subsequent level requires an increasing number of points, requiring students to expend slightly more effort to achieve subsequent advancements. The levels are labeled to help increase interest (e.g., "ultimate bookworm", "serious strategist", etc.), and also help to serve as global indicators of progress across texts.

Points can also be used to "purchase" rewards within the system (bottom box in Figure 1). One of the options available as a reward is for students to change aspects of the learning environment. They can spend some of their iBucks to choose a new tutor agent, change the interface to a new color scheme, or update the appearance of their personal avatar. These features provide students with a substantial amount of control and personalization, and have been designed as purchasable replacements, rather than always available options, to help reduce off-task behaviors (such as switching back and forth between agents).

Lastly, a suite of eight educational mini-games have been designed and incorporated within the iSTART-ME extended practice module. Some mini-games require identification of the type of strategy use, while others may require students to generate their own self-explanations. The majority of iSTART mini-games require similar cognitive processes enveloped within different combinations of gaming elements. For example, in Balloon Bust (Figure 2) students are presented with a target sentence and an example self-explanation. The student must decide which iSTART strategy was used in the self-explanation and then click on the corresponding balloons. There are also three other mini-games which focus on the same task of identifying

strategies within example self-explanations. These other games each incorporate a new interface with a different combination of game elements, including fantasy, competition, and perceptual aspects (as in Balloon Bust). Though the surface features of these games can differ widely, they have been designed with very similar leveling structures and can all be completed within 10-20 minutes. Students are currently allowed to select any form of practice or mini-game from the selection menu (provided that they have a sufficient amount of iBucks). Future versions of iSTART-ME will allow students to unlock various features as they advance through levels.

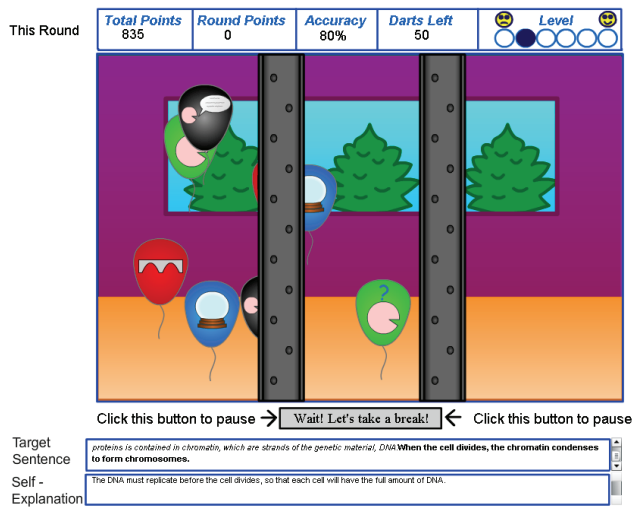


Figure 2. Screenshot of Balloon Bust (identification mini-game)

Current Study

A usability study was conducted that investigated students' attitudes, motivation, and enjoyment during a multi-session interaction with iSTART-ME. The study was small in that few students participated, but it was time intensive because it included seven separate sessions. Students' participation in the study fulfilled a research component to a summer internship program.

Procedure

Ten college students completed a pretest questionnaire that assessed attitudes towards technology, expectations of computers, and motivation to participate. Students interacted with the full iSTART-ME system across seven sessions, each of which took place on different days, over the course of three weeks. Each session ranged from one to two hours (for a total of 8 hours), and at the beginning of each session, participants filled out a brief likert-scale survey related to their experience during the previous session and how they were currently feeling. These questions were asked at the beginning of each session to ensure that all questions would be answered, regardless of time constraints at the end of a particular session.

During the first session all students began iSTART and

successfully completed both the Introduction and Demonstration modules (two hours). Beginning with the second session (sessions 2 through 7 were one hour each), students progressed through the tutoring system at their own pace and therefore not all students experienced the same iSTART components at the same time. Several students completed the regular practice and transitioned into the selection menu during the second session, while a few other students did not reach the selection menu until the third or possibly fourth sessions. Ultimately, all students completed the training modules and subsequently interacted with the new game-based extended practice selection menu for the remainder of the study.

Results

The pre-session survey questions were analyzed to investigate attitude changes over time as students transitioned from the original core iSTART components (introduction, demonstration, regular practice) into the new game-based iSTART-ME (selection menu and games).

The first four questions of the pre-session survey pertained to the participant's experience during the previous session. The survey question means and standard deviations are presented in Table 1 (graphed results in Figure 3). These four questions assessed the overall experience, level of enjoyment, presence of boredom, and any technical problems with the system during the most recent session. The students clearly indicated that they did not like the Introduction and Demonstration modules during their first session (the first three means under Session 2). However, examining the participants' ratings across sessions suggests that both overall experience and enjoyment levels increased as the students progressed through the system and encountered more game-based aspects of iSTART-ME. Additionally, participants' ratings of their boredom tended to decrease as the sessions progressed. Students initially rated a high level of boredom, and that value declined as the sessions progressed. The results from these first questions suggest that students' interaction with the game-based elements may be related to improved perceptions of iSTART-ME.

In addition to information about the previous session, the pre-session surveys also asked students four questions about their current feelings, anticipation, motivation, and competitive drive (bottom of Table 1 and Figure 4). The questions pertaining to feelings, anticipation, and motivation were all rated low during the first survey (all had values near or less than 2). However, across the remaining sessions the ratings for these questions increased, and ultimately all of them ended with an average of three or above. The small dip in scores for the final session may be partially due to the students' knowledge that the remainder of that session was going to be answering survey questions. The results for the current session survey questions further suggest that students' attitudes and outlook converged towards positive assessments as they became more familiar with the gaming environment.

Table 1. Pre-session survey questions about the previous session (means & SD, n=10).

Survey Question	Session					
	2	3	4	5	6	7
Questions about the previous session						
1 Overall, how would you rate your MOST RECENT SESSION [1-very bad, 6-very good]?	2.38 (0.74)	3.71 (1.25)	3.60 (1.51)	3.11 (1.36)	3.78 (1.09)	4.13 (1.36)
2 To what extent did you enjoy your experience [in the previous session, 1-not at all, 6-very much]?	1.75 (1.04)	2.43 (1.51)	3.10 (1.37)	2.67 (1.41)	3.22 (1.09)	3.38 (1.30)
3 To what extent were you bored during your experience [in the previous session, 1-never, 6-all the time]?	5.25 (1.04)	4.14 (1.77)	3.80 (1.23)	4.11 (1.45)	3.67 (1.12)	3.00 (1.41)
4 To what extent did you have problems with the program during your experience [in the previous session, 1-never, 6-all the time]?	2.25 (1.39)	2.14 (1.46)	2.50 (1.43)	1.78 (0.83)	2.44 (1.51)	2.13 (1.25)
Questions about the current session						
5 Overall, how are you feeling about TODAY'S SESSION [1-very negative, 6-very positive]?	2.25 (1.28)	3.71 (1.38)	3.50 (1.35)	3.33 (1.73)	4.11 (1.76)	3.63 (1.77)
6 Are you looking forward to participating in TODAY'S SESSION [1-not at all, 6-very much]?	1.38 (0.52)	2.14 (1.07)	2.60 (1.17)	2.22 (1.39)	3.33 (0.74)	3.00 (1.25)
7 Do you feel motivated to participate in TODAY'S SESSION [1-not at all, 6-very much]?	1.63 (1.36)	2.86 (1.09)	2.80 (1.36)	2.33 (1.32)	3.44 (1.04)	3.13 (1.51)
8 Do you plan to do your best and try to win during TODAY'S SESSION [1-not at all, 6-very much]?	3.38 (1.41)	4.14 (1.09)	4.30 (1.30)	4.11 (1.35)	4.33 (1.04)	4.25 (1.77)

Questions related to the Previous Session

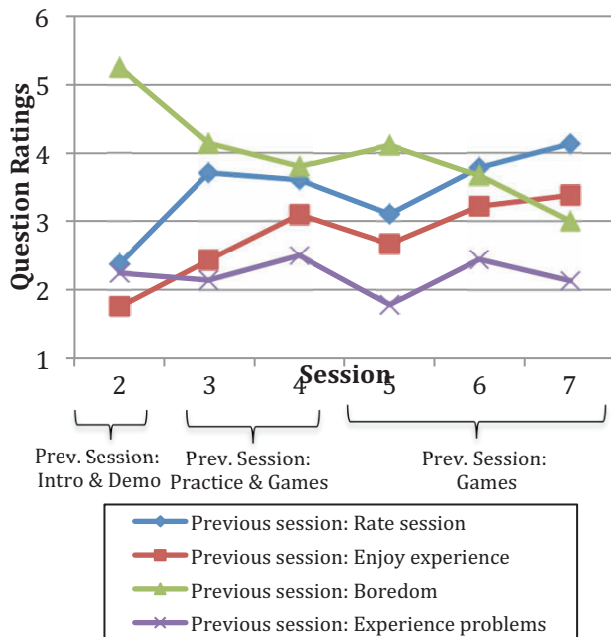


Figure 3. Pre-session survey rating means for the Previous Session.

Questions related to the Current Session

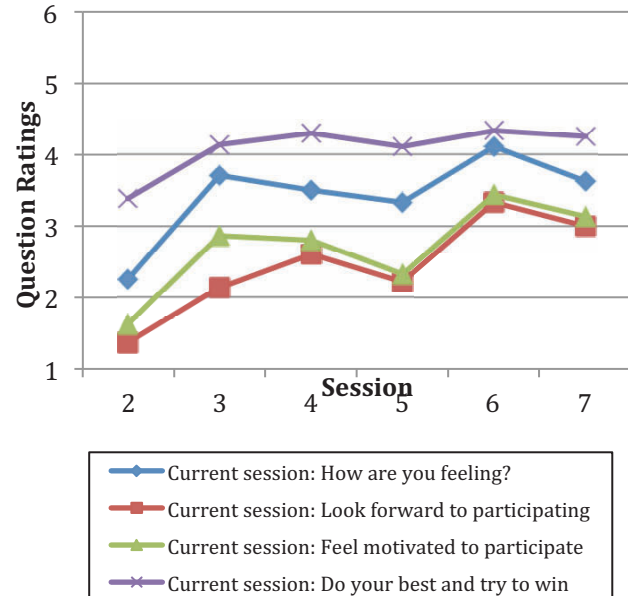


Figure 4. Pre-session survey rating means for the Current Session.

To further investigate the attitude trends across sessions, correlations were performed on the relation between each of the pre-session survey questions and the session number (see Table 2 for correlation results).

Table 2. Correlations between survey questions and session number (i.e., number of days within the study 1-7).

Survey Question	Pearson r
1 Previous session: Rate session	.347*
2 Previous session: Enjoy experience	.384*
3 Previous session: Boredom	-.433*
4 Previous session: Experience problems	-.019
5 Current session: How are you feeling?	.267
6 Current session: Look forward to participating	.420*
7 Current session: Feel motivated to participate	.304*
8 Current session: Do your best and try to win	.146

* $p < .05$.

The correlations presented in Table 2 suggest that students' overall reaction to iSTART-ME was positive and that it improved over time. Specifically, the more students interacted with iSTART-ME the more they liked the system, they enjoyed the experience more, they looked forward more to participating, and they felt more motivated. Additionally, students reported a consistent decrease in boredom across sessions. In fact, the decline in boredom was the strongest effect among all of the survey results. These results indicate that participants' attitudes towards the system continued to improve even after interacting with the system over the course of several weeks.

Conclusions

The overarching goal of the iSTART-ME project is to further our understanding of the benefits of adding game-based elements to ITSs (coined ITaG, Intelligent Tutoring and Games in McNamara et al., 2009). The current usability experiment is a first step in assessing a fully implemented ITaG built on top of an existing ITS. This study focused on investigating the potential motivating effects of situating an ITS within a game-based environment. This usability experiment involved a relatively small number of participants that completed multiple sessions of training with iSTART-ME. Results indicate that the students' attitudes and motivation improved as they continued to interact with the system. Specifically, participants did not enjoy the interaction during the initial introduction and demonstration modules of iSTART. However, their attitudes and motivation significantly improved once they began interacting with the practice module and the game-based aspects of the system.

This long-term interaction study provides an advantage over typical single session experiments, by allowing for the investigation of motivational effects across different timelines. These results support the main goal of the project,

and provide further evidence that games have the potential to increase student engagement and persistence within a learning environment. This finding creates a promising foundation from which we can extend subsequent work and further contribute to the scientific research on game-based learning.

The development of iSTART-ME allows us to examine the effectiveness of a combined ITaG system, as well as to more systematically evaluate the effects of game components in the context of an ITS. The current system has been designed with distinct and separable features so that multiple combinations can be tested across a variety of experiments. Future work with iSTART-ME includes both global and local assessments of game-based performance. An in-depth efficacy study is anticipated that will offer a large scale evaluation of user performance, engagement, and persistence across time. Additionally, several small-scale experiments are being implemented to address the interactions between specific game components.

Both the current and future work of iSTART-ME helps to further the field of intelligent tutoring systems and game-based learning. While the current results are based on a relatively small number of participants, they provide an invaluable foundation for our future work, and offer further support for a developing field of research. Ultimately, we expect hybrid ITaG learning environments to dramatically impact, the effectiveness of computer-based training as well as further our understanding of the complex motivational aspects of learning environments and their interplay with learning.

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