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The Impact of Performance Orientation on Students' Interactions and Achievements in an ITS

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Abstract

Research on individual differences indicates that students vary in how they interact with and perform while using intelligent tutoring systems (ITSs). However, less research has investigated how individual differences affect students' interactions with game-based features. This study examines how learning outcomes and interactions with specific game-based features (off-task personalization vs. on-task mini games) within a game-based ITS, iSTART-ME, vary as a function of students' performance orientation. The current study (n=40) is part of a larger study (n=126) conducted with high school students. The analyses in this study focus on those students assigned to iSTART-ME. Results indicate that students with higher levels of performance orientation perform better during training, progress further within the system, and interact less frequently with off-task game-based features. These results provide further evidence that individual differences play an important role in influencing students' interactions and achievement within learning environments.

Introduction

One focus of educational research is on student individual differences and how those differences impact the effects of certain pedagogical approaches. Research has shown that differences in students' ability levels, attitudes, and motivation critically impact their interactions and performance within the classroom (Ames & Archer, 1988). Likewise, as educators increasingly integrate new technologies within the classroom, questions emerge concerning the role of individual differences in moderating the effects of educational technologies. For example, several researchers have focused on students' engagement and style of interactions with intelligent tutoring systems (ITSs), and how those differences among students affect achievement and learning outcomes (e.g., D'Mello, Picard, & Graesser, 2007; Baker et al., 2008; Jackson, Graesser, & McNamara, 2009).

This study focuses on the effects of individuals' *performance orientation* on interactions and learning within a game-based ITS. Performance orientation (also known as ego orientation or ego-involvement) is an attitude that emphasizes the importance of superior individual achievement compared to others on designated tasks (Ames, 1992). According to this perspective, students perceive learning as secondary to achievement and the recognition they receive from succeeding in the task (Ames, 1992). High levels of performance orientation in the classroom are negatively related to learning outcomes (see Pintrich, 2000, for a review). So, those students who are focused on achievement relative to others rather than the intrinsic benefits of learning do more poorly on learning tasks.

One explanation for these negative learning outcomes is that students who exhibit high levels of performance orientation are more likely to divert attention and effort away from the learning task (Fisher & Ford, 1998). These students exhibit more concern about how their performance will measure up to their peers and seem to be less concerned with the learning goal. Therefore, they are more likely to seek out shortcuts or loopholes, indirectly negatively impacting learning (Fisher & Ford, 1998).

Taking shortcuts in an ITS environment has been referred to as *gaming* the system. Gaming is defined as getting through the system as successfully and as fast as possible (Baker et al., 2004), usually by finding loopholes and shortcuts. Baker and colleagues expected performance orientation to be positively related to the prevalence of gaming behaviors in an ITS. This hypothesis followed from the assumption that those who game a system are analogous to students in a classroom who show more concern with acknowledgment and less concern with learning. While this reasoning appears quite sound, alas, no significant relation has been found between gaming behaviors and performance orientation (Baker et al., 2008).

Hence, the hypothesis that performance orientation is related to gaming the system has not held up.

In the current study, we explore an alternative hypothesis. We propose that performance orientation is related to achievement and interactions in educational technologies, but not in the way expected by Baker and colleagues (2004, 2008). While students with high levels of performance orientation may not *game* the system per se, they may still interact with it differently than those with lower levels of performance orientation. For instance, if high performance oriented students are focused on outshining others, they may also focus their efforts on system features that promote incentives or rewards. This expectation is particularly relevant to game-based ITSs.

Game-based features have been shown to increase student engagement and enjoyment within learning environments (Rai & Beck, 2012; Rai, Beck, & Heffernan, 2010; Jackson & McNamara, 2011, 2012). Hence, there is an increased interest in incorporating game-based features into ITSs to enhance student engagement, particularly during extended training sessions (Cordova & Lepper, 1996; McNamara, Jackson, & Graesser, 2009). However, while game-based features may enhance engagement, they may also act as seductive distracters (Rai, Beck, & Heffernan, 2010). Seductive distracters have the unfortunate consequence of pulling students' attention away from the learning tasks and consequently decreasing performance (Harp & Mayer, 1998).

Whether game-based features increase engagement or distract from learning may depend on the type of feature. Game-based features can be tangential to learning (off-task; e.g., avatar personalization or navigational choices) or an extension of the learning task (on-task; e.g., extended practice mini-games or practice quests). These features can also vary in the amount of incentives they provide based on student achievement within the system. Although research has investigated the impact of game-based features on enjoyment and learning, very little work has investigated why students choose to interact with specific types of features versus others. Understanding the influence of individual differences on system interactions is crucial for building adaptive systems that promote learning.

In the current study, we investigate the relations between individual differences in performance orientation and system interactions, system achievements, and learning gains. Using the iSTART-ME system, we examine how students' interactions with personalizable features (i.e., editable avatars, changeable background themes, and changeable pedagogical agents) and mini-games vary as a function of self-reported levels of performance orientation. In the context of iSTART-ME, we expected that high performance oriented students would be more likely to interact with features that provide incentives (e.g., trophies, currency, badges). In turn, by doing so, they would also be more likely to veer away from game-based features that do not overtly promote a measure of success.

iSTART

Interactive Strategy Training for Active Reading and Thinking (iSTART) is an ITS that was designed to improve students' comprehension of science texts through the instruction of reading strategies (McNamara, Levenstein, & Boonthum, 2004). This system is divided into three modules: introduction, demonstration, and practice. During the introduction module, students interact with three pedagogical agents who discuss definitions and show students examples of reading comprehension strategies. After the introduction module is completed, students are transitioned into the demonstration module. In this model students watch as two pedagogical agents apply the previously introduced reading strategies to texts. Students are then asked to identify which strategy is being used by the agents in each text. Finally, the practice module of iSTART provides students with an opportunity to apply the strategies they have seen to science texts. In this module, students are shown two example texts and are asked to generate self-explanations for target sentences. A pedagogical agent provides formative feedback on students' use of the comprehension strategies. An extended practice module provides the means for additional practice over weeks or months.

A computational algorithm within iSTART assesses the quality of students' self-explanations and guides the feedback that they receive from the system. Self-explanations are assessed on a scale of 0 to 3. A score of "0" is provided when students' self-explanations are composed of irrelevant information or are too short. A score of "1" is given when self-explanations do not elaborate upon the provided information in the text. A score of "2" indicates that students' self-explanations incorporate inferences from the text, and a"3" indicates that the self-explanation incorporates information about the text at a global level.

iSTART-ME

The practice module and extended practice module within iSTART enhance students' ability to self-explain and comprehend challenging text; however, the repetitive nature of these modules can cause some students to disengage (Bell & McNamara, 2007; Jackson & McNamara, 2012). iSTART-ME (Motivationally Enhanced) expands upon the original iSTART system by incorporating educational games and adding game-based features into the interface of the original system (Jackson, Boonthum, & McNamara, 2009). This system incorporates the three modules from the original iSTART system: introduction, demonstration, and practice. However, an added module, called extended practice, was added to increase students' engagement and enjoyment. In this module students interact with a game-based interface that was designed to reinforce the comprehension strategies.

The iSTART-ME interface is controlled through a selection menu where students can choose to play games, read new texts, and interact with game-based features (see Figure 1 for menu screenshot). When students choose to interact with texts and play games, they earn points within in the system called iBucks. These iBucks serve as in-system currency and can be used to unlock the game-based features on the interface.

Figure 1. Screenshot of iSTART-ME Menu

Students can earn iBucks through three different methods of generative practice: Coached Practice, Showdown, and Map Conquest. Coached Practice is the form of generative practice from the original iSTART system. Showdown and Map Conquest are both game-based generative practice modules that use the same assessment algorithm as Coached Practice. All three of these game-based practice modules require students to generate self-explanations and practice applying the strategies (just as they do within Coached Practice).

As students accumulate more iBucks, they advance to higher levels, where new features are unlocked. Levels range from 0 (starting level for all students) to 25 (the maximum level that students can achieve). Each level requires more iBucks than the previous in order to advance to a new level. This ensures that students must exert more effort as they progress through higher levels within the system. Students can use their earned iBucks to interact with different game-based features within the ITS interface. There are two primary types of game-based features that students can use points to interact with: mini-games and personalizable features.

Mini-games were designed to add game-based practice for strategies that the student had previously seen within the iSTART-ME system. For instance, in Balloon Bust students are presented with a text and then provided a sample self-explanation. They must decide what strategy was used to generate each sample self-explanation by clicking on a balloon that represents each strategy (see Figure 2). Within mini-games, students can earn points and advance to higher iSTART levels based on their performance. Each mini-game play costs students 300 of their earned iBucks.

Personalizable features were designed to engage students' interest by allowing them to personalize and control their environment as a reward for performing well within the game-based learning tasks. Personalizable features include editable avatars, customizable background themes, and interchangeable pedagogical agents. For instance, students can use their earned iBucks to change their avatar's hair colors or clothing (see top left of Figure 1). Each personalization action requires students to spend 300 of the iBucks that they have earned. These features were designed as off-task incentives and do not contribute to their earned points or iSTART levels within the system.

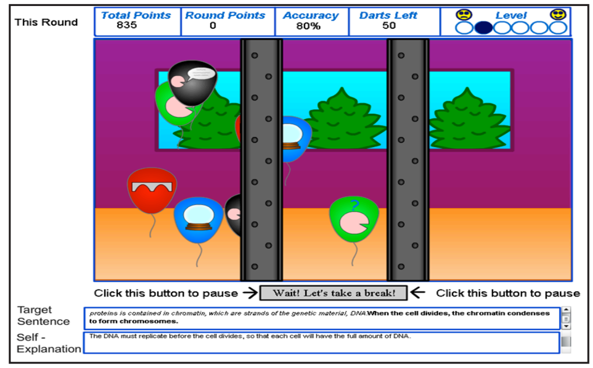

Figure 2. Screenshot of Balloon Bust

Methods

Participants in this study included 40 high school students from a mid-south urban environment. The sample of students included in the current work is a subset of 125 students who originally participated as part of a larger study that compared three conditions: iSTART-ME, iSTART-original, and no-tutoring control. Our study focuses solely on the students who were assigned to the iSTART-ME condition. These students had access to the full system interface where the game-based features (personalizable features and mini-games) were available.

All 40 students in the iSTART-ME condition completed an 11-session experiment that consisted of a pretest, 8 training sessions, a posttest, and a delayed retention test. During the first session, participants completed a pretest including a self-report survey that assessed individual differences in affect, motivation, and attitudes toward technology and games. During the 8 training sessions, the iSTART-ME participants took part in the extended practice portion of the experiment. Each of these sessions lasted a minimum of 1 hour. At the beginning of each session, students completed a short questionnaire assessing their current mood and perception of the system. After this questionnaire, students were transitioned to the iSTART-ME interface, where they were free to interact with the system as they chose for an hour. During session 10, students completed a posttest, which included the same measures administered at pretest. Finally, approximately 1 week after the posttest, each student returned to complete a retention test, which contained measures similar to the pretest and posttest (i.e., self-explanation and attitudinal measures).

Students' performance orientation rating was measured at pretest through a self-report survey in which students were asked to rate themselves and their attitudes toward educational technology. To assess students' performance orientation, each student indicated the relative importance of the following statement, "It is important for me to do better than others within the system." This rating was on a scale from 1 (it is not important to me) to 6 (it is very important to me). This was the only measure of performance orientation in the pretest survey; therefore, the reliability of the measure could not be calculated. Students' reading comprehension ability was assessed using the Gates-MacGinitie Reading Test (MacGinitie & MacGinitie, 1989). Self-explanations were scored using the automated iSTART assessment algorithm (McNamara et al., 2007).

Results

The current study investigated how performance orientation related to differences in student behaviors and achievements within iSTART-ME, a game-based ITS. Using the frequency of each student's interaction with on-task and off-task features, we examined how individual differences influenced interactions within the system. In the current study, off-task behaviors included editing an avatar, customizing the background theme, or changing a pedagogical agent, whereas on-task behaviors included choosing to play extended practice mini-games. Additionally, we measured each student's daily achievements through iSTART levels, points earned, and the quality of daily self-explanation scores within the system. Daily self-explanations were generated through students' interactions with generative practice games and generative mini-games.

In order to assess students' system interactions, we computed the tendency of each student to spend their earned iBucks on game-based features by calculating the proportion of earned iBucks that each student spent on game-based features (total iBucks spent / total iBucks earned). This provides each student's tendency to spend iBucks within iSTART-ME, which we refer to as *spendency*. We also calculated the proportion of iBucks that each student spent on personalizable features (iBucks spent on personalization / total iBucks spent) and the proportion of iBucks that students spent on mini-games (iBucks spent on mini-games / total iBucks spent). This provided the proportion of iBucks spent on both personalizable features and on mini-games.

Pearson correlations were calculated between students' levels of performance orientation, self-explanation quality, prior motivation to learn, study expectations, and system interactions. Correlations in this table were grouped by conceptual relevance. As shown in Table 1, seven variables were significantly correlated with performance orientation. We discuss those correlations in the order they appear in Table 1.

Results indicated that there was no relation between total points earned and performance orientation. However, students who reported a higher level of performance orientation tended to spend a lower proportion of their earned iBucks (i.e., they displayed lower spendency). Moreover, those with higher performance orientation who did spend iBucks, were less likely to spend iBucks on personalizable features (off-task, non-incentive earning features). Hence, students with high performance orientation levels were not earning more or less iBucks in the system; they were simply spending a lower proportion of their earned iBucks. Additionally, when these students did spend system currency they chose to interact less frequently with off-task features.

The correlational results also revealed a significant positive relation between students' performance orientation levels and their expected enjoyment, prior motivation to learn, and confidence that they could learn from the system. Overall, high performance orientation students were more likely to show positive perceptions toward the system.

Finally, we also see that performance orientation is significantly related to iSTART levels and daily self-explanation quality. More specifically, students who reported higher levels of performance orientation tended to reach higher levels within the system and received higher scores on their self-explanations during daily training. However, performance orientation was not related to self-explanation scores at either posttest or retention test.

Table 1

Correlations between performance orientation and system interactions, perceptions, and achievements

Dependent Measure	Performance Orientation
Total iPoints earned	.176
Spendency	-.361 *
Prop spent on mini-games	.129
Prop spent on personalization	-.367 *
Expected enjoyment	.600 **
Motivation to learn	.436 **
Confident I can learn	.809 **
iSTART level	.317 *
Daily SE scores	.316 *
Posttest SE scores	.062
Retention SE scores	.302

*$p < .05$; ** $p < .01$

The current study investigated how performance orientation impacted students' outcomes and interactions within the system. Results revealed that there was a significant relation between system interactions, system achievement, daily self-explanation scores, system perceptions, and students' levels of performance orientation.

We were also interested in gaining a deeper understanding of the impact that performance orientation has on the system's learning objectives (i.e., to improve the quality of self-explanations). Specifically we investigated the impact of students' orientation on daily self-explanation quality above and beyond students' initial abilities and motivation at pretest. A regression analysis was conducted to examine how students' pretest self-explanation scores, prior motivation, and self-reported performance orientation influenced daily self-explanation training scores. The three independent variables were entered as predictors of daily self-explanation scores in a forced-entry linear regression. The overall model for this regression was significant, $F(1,36)= 4.617$ $p < .05$, $R^2=.355$. The first block of the regression (i.e., Model 1 in Table 2) shows that pretest self-explanation quality significantly predicts students' ability to self-explain during training; this is to be expected. Model 2 shows that students' prior level of motivation to learn does not account for a significant amount of variance in daily self-explanation quality. Within Model 3, both pretest self-explanation scores ($t = 3.73$ $p <.001$) and performance orientation ($t = 2.15$, $p <.05$) were significant predictors of daily self-explanation scores. Pretest motivation was not a significant predictor ($p>.05$). Hence, performance orientation was a significant predictor of daily self-explanation quality above and beyond initial self-explanation ability and prior motivation (with a unique R^2 of .083).

Table 2
Linear regression analyses predicting daily self-explanation (SE) score

Variable	B	SE	β	ΔR^2
Model 1				.263**
Pre-Test SE	.414	.112	.513**	
Model 2				.009
Pre-Test SE	.397	.116	.492**	
Prior Motivation	.048	.071	.096	
Model 3				.083*
Pre-Test SE	.414	.111	.513**	
Prior Motivation	-.024	.076	-.048	
Performance Orientation	.122	.057	.320 *	

*$p < .05$; ** $p < .01$

Conclusions

iSTART-ME was designed as a game-based ITS that maintains student engagement over an extended time period while students practice applying self-explanation and comprehension strategies. Although game-based features have been shown to increase student engagement (Jackson & McNamara, 2011), little work has been conducted to investigate how individual differences may impact the frequency of student interactions with these features. Our study investigated this issue by examining how individual differences in performance orientation impacted the types of interactions that students exhibited within the iSTART-ME interface. We also examined how this orientation affected daily system achievements throughout the eight training sessions.

Results from the current study indicated that students' self-reported performance orientation impacted their interactions with distinct features. Specifically, as ratings of performance orientation increased, students had a lower tendency to spend their earned iBucks. However, when they did spend iBucks, they were less likely to spend them on personalizable features. One reason for this behavior could be that these features provided the students with no additional earned incentives (i.e., points or iBucks). Performance oriented individuals' focus on their own achievements compared to others, and these personalizable features do not indicate to students how well they are doing or give them any additional recognition.

Students with higher levels of performance orientation were also more likely to reach higher iSTART levels within the system. iSTART levels are based on points earned within the system and are an outward measure of achievement that is displayed on the interface and could be used by students to gauge their individual performance in the system. The results from the current study suggest that individual differences in performance orientation are significantly related to students' selection and success for tasks that outwardly reflect abilities within the system.

In the current study the only measure of learning that was impacted by performance orientation was students' average daily self-explanation score. As students' ratings of performance orientation increased, so did their daily self-explanation score. Daily self-explanation scores come from students' interactions with generative games, where performance is also rewarded with iSTART points. These results indicate that high levels of performance orientation led to stronger training self-explanation scores. However, despite these training effects, there was no relationship between students' levels of performance orientation and their self-explanation scores at posttest or retention test. Consistent with prior research, these results may stem from the fact that high performance oriented individuals are more concerned with achievement (e.g., iSTART levels, points and trophies) than deep learning and retention.

The current study demonstrates the importance of individual differences and their impact on ITS interactions and system achievements. In our study, performance orientation explained variance in students' system interactions and daily system achievements. The level of students' orientation also accounted for the quality of daily self-explanations over and above pretest self-explanation ability and prior motivation.

Future investigations of individual differences may give us a better understanding of why some features are preferred by some students, but ignored by others. Future work should also be directed at investigating and identifying how individual differences may impact overall learning. Understanding how these differences impact the way in which students approach and interact with specific aspects of systems will allow us to continue to build interactive learning systems that adapt to students' strengths and preferences.

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References

Ames, C. 1992. Classrooms: Goals, Structures, and Student Motivation. *Journal of Educational Psychology* 84: 261-271.

Ames, C.; and Archer, J. 1988. Achievement goals in the classroom: Student learning strategies and motivation processes. *Journal of Educational Psychology,* 80*:* 260-267.

Baker, R. S.; Corbett, A. T.; Koedinger, K. R.; and Wagner, A. Z. 2004. Off-task Behavior in the Cognitive Tutor Classroom: When Students "Game the System." *In Proceedings of ACM CHI 2004: Computer-Human Interaction*, 383–390. New York: ACM.

Baker, R.; Walonoski, J.; Heffernan, N.; Roll, I.; Corbett, A.; and Koedinger, K. 2008. Why Students Engage in "Gaming the System" Behavior in Interactive Learning Environments. *Journal of Interactive Learning Research* 19: 185-224.

Bell, C.; and McNamara, D. S. 2007. Integrating iSTART into a High School Curriculum. In Proceedings of the 29th Annual Meeting of the Cognitive Science Society, 809-814. Austin, TX: Cognitive Science Society.

Cordova, D. I.; and Lepper, M. R. 1996. Intrinsic Motivation and the Process of Learning: Beneficial Effects of Contextualization, Personalization, and Choice. *Journal of Educational Psychology* 88: 715-730.

D'Mello, S.K.; Picard, R.W.; and Graesser, A.C. 2007 Towards an Affect-Sensitive AutoTutor. Special Issue on Intelligent Educational Systems, *IEEE Intelligent Systems* 22: 53–61.

Fisher, S. L.; and Ford, J. K. 1998. Differential Effects of Learning Effort and Goal Orientation on Two Learning Outcomes*. Personnel Psychology* 51: 392 -420.

Harp, S. F.; and Mayer, R. E. 1998. How Seductive Details do their Damage: a Theory of Cognitive Interest in Science Learning. *Journal of Educational Psychology* 90: 414–434.

Jackson, G. T.; Boonthum, C.; and McNamara, D. S. 2009. iSTART-ME: Situating Extended Learning within a Game-Based Environment. In H.C. Lane, A. Ogan, & V. Shute (Eds.), *Proceedings of the Workshop on Intelligent Educational Games at the 14th Annual Conference on Artificial Intelligence in Education*, 59-68. Brighton, UK: AIED.

Jackson, G. T., Graesser, A. C., and McNamara, D. S. 2009. What Students Expect May have More Impact than What they Know or Feel. In V. Dimitrova, R. Mizoguchi, B. du Boulay, & A.C. Graesser (Eds.), *Artificial Intelligence in Education; Building Learning Systems that Care; From Knowledge Representation to Affective Modeling,* 73-80. Amsterdam, The Netherlands: IOS Press.

Jackson, G. T.; and McNamara, D. S. 2011. Motivational Impacts of a Game-Based Intelligent Tutoring System. In R. C. Murray & P. M. McCarthy (Eds.), *Proceedings of the 24th International Florida Artificial Intelligence Research Society (FLAIRS) Conference*, 519-524. Menlo Park, CA: AAAI Press.

Jackson, G. T.; and McNamara, D. S. in press. Motivation and Performance in a Game-Based Intelligent Tutoring System. *Journal of Educational Psychology Special issues on Advanced Learning Technologies.*

MacGinitie, W. H.; and MacGinitie, R. K. 1989. Gates MacGinitie reading tests. Chicago: Riverside.

McNamara, D. S.; Jackson, G. T.; and Graesser, A. C. 2009. Intelligent Tutoring and Games (iTaG). In H.C. Lane, A. Ogan, & V. Shute (Eds.), *Proceedings of the Workshop on Intelligent Educational Games at the 14th Annual Conference on Artificial Intelligence in Education*, 1-10. Brighton, UK: AIED.

McNamara, D. S., Boonthum, C., Levinstein, I. B., and Millis, K. 2007. Evaluating Self-Explanations in iSTART: Comparing Word-Based and LSA Algorithms. In T. Landauer, D.S. McNamara, S. Dennis, & W. Kintsch (Eds.), Handbook of Latent Semantic Analysis, 227-241. Mahwah, NJ: Erlbaum.

Pintrich, P. R. 2000. The Role of Goal Orientation in Self-Regulated Learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation*, 451–502. San Diego: Academic Press.

Rai, D.; and Beck, J. E. 2012. Math Learning Environment with Game-Like Elements: An Experimental Framework. *International Journal of Game Based Learning* 2: 90-110.

Rai, D.; Beck, J. E.; and Heffernan, N, T. 2010. Mily's world: Coordinate geometry learning environment with game-like properties*, Tenth International Conference on Intelligent Tutoring Systems,* Pittsburgh, USA.

Rodrigo, M. M. T.; Baker, R. S. J. D.; D'Mello, S.; Gonzalez, M. C. T.; Lagud, M. C. V.; Lim, S. A. L.; Macapanpan, A. F.; Pascua, S. A. M. S.; Santillano, J. Q.; Sugay, J. O.; Tep, S.; and Viehland, N. J. B. 2008. Comparing Learners' Affect while Using an Intelligent Tutoring System and a Simulation Problem Solving Game. In *Proceedings of the 9th International Conference on Intelligent Tutoring Systems*, 40-49. Berlin, Heidelberg: Springer-Verlag.