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Game Features and Individual Differences: Interactive Effects on Motivation and Performance

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Abstract. To optimize the benefits of game-based practice within Intelligent Tutoring Systems (ITSs), researchers examine how game features influence students' motivation and performance. The current study examined the influence of game features and individual differences (reading ability and learning intentions) on motivation and performance. Participants (n = 58) viewed lesson videos in iSTART-2, an ITS designed to improve reading comprehension skills, and practiced with either a game-like activity or a minimally game-like activity. No main effects of game environment were observed. However, there was an interaction between game environment and pretest learning intentions in predicting students' self-reported effort. The correlation between learning intentions and self-reported effort was not significant for students who practiced with the more game-like activity, whereas it was for students who practiced in the less game-like activity. We discuss the implications for this interaction and how it might drive future research.

Keywords: Game-based learning, Intelligent Tutoring Systems, Motivation

1 Introduction

Intelligent Tutoring Systems (ITSs) have been successfully implemented across a variety of domains [1]. However, these systems often provide repetitive and prolonged practice, which can result in disengagement and boredom [2]. One approach to enhance motivation is through the inclusion of games and game-like features [3]. Games aim to leverage students' enjoyment to foster interest and engagement in a system, leading to an increased motivation to persist in practice, though there have been mixed findings about the link between games and motivation [4]. To best make use of educational games, researchers seek to understand how different game features function for different domains and contexts [3], and how students' individual characteristics influence the impact of game features [5, 6]. Toward achieving these goals, we investigated the effects of game features on motivation and performance. Subsequently, we examined how motivation and performance are influenced by the interaction between key individual differences and game features.

2 Current Study and Results

The context of the current study is the Interactive Strategy Training for Active Reading and Thinking-2 (iSTART-2) system. iSTART-2 is a game-based ITS designed to enhance comprehension abilities through self-explanation strategy lessons and strategy practice games [7]. Previous work has compared game-based versions of iSTART to non-game based versions and found that over time, students (including those with lower reading abilities) equally benefitted from the game-based version and the non-game based version [6]. However, the game-based version yielded higher enjoyment and motivation [7]. Because these studies included an array of games and game types, however, it is difficult to pinpoint the effects of particular features.

With this study, we aim to disentangle the relative benefits (or costs) of game features by including two between-subjects conditions corresponding to an activity that is minimally game-like (Strategy Identification) and an activity that includes game features (Strategy Match). Each activity involved the same cognitive task that requires students to read a scientific passage and select which iSTART-2 strategies were used to generate example self-explanations. Strategy Identification only provided accuracy feedback. Strategy Match also included points and levels. Points were rewarded for correct answers, with point bonuses for selecting correct answers consecutively; students advanced through levels as their point total increased. We make comparisons between students who practiced with these activities to help answer our research questions: How does posttest motivation and performance differ as a function of game environment? Do game features affect the relationship between individual differences (reading ability and learning intentions) and students' motivation and performance?

Participants were 58 high school students and recent high school graduates who were paid to complete this 3-hour study. They were randomly assigned to practice with either Strategy Identification (n=29) or Strategy Match (n=29). One student was removed due to a computer error. All students completed a pretest that included measures of reading ability (Gates-MacGinitie Reading Test, 4^{th} ed.), motivation [8], and self-explanation ability [7]. Next, students watched self-explanation lesson videos, and then spent 45 minutes practicing with either Strategy Identification or Strategy Match. Last, students completed a posttest which was similar to the pretest. Performance on pretest and posttest self-explanations was quantified by calculating a score from 0 to 3 on each self-explanation using an automated scoring algorithm [9].

Motivation and Performance. Between-participants ANCOVAs were used to test differences across the two game environments (Strategy Identification and Strategy Match) in three posttest motivation dimensions: reported effort, performance assessment, and emotional state. The covariates included pretest motivation dimensions to account for any pretest differences that emerged despite random assignment. No main effects of game environment were significant (Fs < 2, ps > .10). A between-participants ANCOVA was used to investigate the effect of game environment on posttest self-explanation quality, with pretest quality serving as the covariate. There was no main effect of game environment ($F < 1$, $p > .10$). Scores on the self-explanations at posttest were, however, lower than at pretest for participants in both the Strategy Identification and Strategy Match conditions. A repeated-measures, mixed ANOVA with test (pretest, posttest) as a within-participants factor and game environment as a between-participants factor showed that posttest scores were significantly lower than pretest scores [$F(1, 55) = 28.42$, $p < .001$, $\eta_p^2 = .34$]. This finding may be attributable to fatigue and the limited time practicing in the system.

Interactions with Individual Differences. To explore the question of how game environment moderates the relationship between individual differences and students' motivation and performance, we conducted hierarchical multiple regression analyses, which allowed us to determine if a model including an interaction term was significantly more predictive than a model without.

We first conducted a hierarchical multiple regression with *posttest reported effort* as the dependent variable. Model 1 included *reading ability* and game environment as predictors (for all regressions, Strategy Identification was dummy coded as 0 and Strategy Match as 1), and was not significantly predictive [$F(2, 54) = 0.96$, $R^2 = .034$, $p = .390$]. Model 2 added the interaction term between reading ability and game environment and was also not significant [$F(3, 53) = 0.67$, $R^2 = .037$, $p = .573$]. We conducted a second hierarchical multiple regression with posttest reported effort as the dependent variable. Model 1 included *learning intentions* and game environment as predictors and was significantly predictive of reported effort [$F(2, 54) = 11.08$, $R^2 = .291$, $p < .001$]. Students with higher learning intention scores reported exerting more effort during their interactions with iSTART-2. Model 2 added the interaction term between learning intentions and game environment, and was significantly more predictive [$F(1, 53) = 4.99$, $\Delta R^2 = .061$, $p = .030$]. To examine this effect, we calculated the correlations between learning intentions and posttest self-reported effort. This correlation was stronger for students who practiced with Strategy Identification ($r = .72$, $p < .001$) than with Strategy Match ($r = .30$, $p = .108$). For Strategy Identification (the less game-like activity) students, this means that if they began the study intending to work hard to learn from the task, at posttest they often did report working hard; or if they began the study without the intention to devote much effort to the task, at posttest they tended to report a lack of effort. By comparison, Strategy Match (the more game-like activity) students showed a weaker relationship: students' initial intention to learn did not strongly determine how much effort they later reported exerting.

We conducted similar hierarchical regressions predicting *posttest self-explanation* quality (including pretest self-explanation ability as a predictor to account for pretest differences). However, in the first hierarchical regression, adding the *reading ability* by game environment interaction term only marginally increased the predictive strength of the model [$F(1, 52) = 2.99$, $\Delta R^2 = .032$, $p = .090$]. And in the second hierarchical regression, adding the *learning intentions* by game environment interaction term did not increase the predictive strength of the model [$F(1, 52) = 0.73$, $\Delta R^2 = .010$, $p = .397$]. Thus, game environment did not significantly moderate the relationship between individual differences and performance.

3 Conclusions

This study compared students' motivation and performance after interacting with iSTART-2 using one of two game environments: Strategy Identification, which was minimally game-like, and Strategy Match, which rewarded students with points that advanced them through levels. No differences emerged in comparing motivational measures and performance across conditions. However, evidence emerged that the game environment moderated the relationship between learning intentions and reported effort. Thus, for students who practiced with the less game-like activity, there was a strong relationship between pretest learning intentions and posttest reported effort. However, for students who practiced with the more game-like activity, there was no relationship. The inclusion of game features thus resulted in students deviating from their initial learning intentions (which could be good or bad, depending on their intentions). Note that this project cannot suggest *why* the game features in Strategy Match caused normally strong relationships between self-reported pre-task and post-task motivational measures to break down. Future work focusing on the complex set of relationships between individual differences and game features can help endow ITSs with the ability to target game features to specific groups of students.

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