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IMPACT OF INCENTIVES ON THE USE OF FEEDBACK IN EDUCATIONAL VIDEOGAMES

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on Evaluation, Standards, & Student Testing

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Abstract

Educational videogames can be designed to provide instructional feedback that is responsive to specific actions. However, existing research indicates that students tend to ignore videogame feedback and subsequently use less effective help-seeking strategies. Research on help-seeking in learning environments has primarily focused on the role of cognitive factors, the nature of the help, or issues of timing and frequency. There is a noticeable gap in understanding regarding how to motivate and increase the use of feedback for improved learning. Using a pre-algebra videogame, this study examined the relationship between an incentive to use feedback and math achievement. A randomized-control design was employed, which compared learning outcomes of students who received the incentive to those who did not. Results indicated that students given the incentive to use feedback had significantly higher normalized change scores on math items (d = .53), with stronger effects for students with low academic intrinsic motivation (d = .88 – 1.17).

Introduction

A key benefit of games for learning is that they can be designed to provide instructional feedback responsive to specific student actions. Tailored hints and feedback, or supporting information accessible via general help menus, is the type of help that is often used in help-seeking studies. However, the research on help-seeking indicates that when students reach an impasse, they either use ineffective help-seeking strategies, or avoid seeking help altogether, as reviewed by Aleven et al. (2003).

To understand the relationship between help-seeking and learning, researchers have primarily studied the role of cognitive factors (e.g., self-efficacy), the nature of the provided help (e.g., context-specific versus generalized principles), timing and frequency (e.g., on demand or system-initiated), and how the process of help seeking can be taught explicitly. There is a noticeable gap in understanding regarding how to *motivate* students to effectively seek help and to use feedback.

Consequently, this study focused on learning games where game play was directly integrated and linked with its corresponding academic content. If game play is to require the use, demonstration, and evaluation of the application of knowledge or skills in a particular domain, students may need to know the criteria underlying their progress or lack thereof. Communication of a game's scoring rules can be leveraged to make assessment criteria more explicit and transparent.

This paper describes a study that examined the impact of incentives to access feedback, combined with different degrees of game explanation rules, to math achievement. The learning platform was an educational videogame designed to teach students about fractions.

The Importance of Feedback for Learning

Feedback related to progress in learning tasks can generally have a positive effect on learning (Nyquist, 2003). There are certain conditions that make it effective—specifically, feedback that supports clear understanding of the learning goals or objectives (and the criteria that define good quality), methods for students' to relate his or her performance to the goals, and a clear path or paths to achieve the goals. (Bangert-Drowns et al., 1991; Hattie & Temperley, 2007; Kluger & DeNisi, 1996).

However, the mere presence of feedback, hints, or available help is insufficient for learning. Review of the research on the use of feedback in technology-based environments indicates that students rarely access available feedback voluntarily. This is problematic as the lack of compliance with the treatment greatly reduces any potential effect on the outcomes. For example, Nelson (2007) compared different levels of feedback on student achievement in an immersive learning environment. Results from the study indicate that most students did not access the feedback. Also, between students who were provided extensive feedback and students who were given moderate feedback, there were no statistical differences on the frequency of accessing the hints. In a study that examined the effect of providing user-initiated feedback via a pedagogical agent, Van Eck and Dempsey (2002) also reported low levels of student access to the feedback. The authors concluded that further research is essential to figure out how to promote its use.

Increasing the Use of Feedback in Technology-Based Learning Environments via Incentives

Given the historic barriers, it is not surprising that students avoid seeking help. Research conducted in classroom settings, for example, suggests that some students perceive help-seeking as a public sign of failure and therefore a social stigma (Karabenick & Newman, 2006; Puustinen et al., 2009; Ryan & Pintrich, 1997). Further, in game-based settings, accessing feedback slows the game down, and some games have speed of play as a basis of advancement. In some technology-based environments, accessing feedback or available hints is associated with low proficiency and subsequently discouraged. For example, when a hint is given to a student in the PACT Geometry tutor, the student's visible “skill bar” decreases (Aleven & Koedinger, 2000). In some games, students are penalized when accessing help, (i.e., students lose points when a hint is accessed).

The design approach used in this study adopted the perspective that incentives can communicate what is valued within a given context and promote desired behavior. Rewards and incentives are, after all, a method for signaling those actions or behaviors that are encouraged or discouraged by a particular community. Conveying these expectations is a key process through which individuals learn how to participate in learning and gaming communities (Rogoff, 1900; 2003). The use of an incentive to access feedback may be one potential approach, especially as findings from studies using tasks with initial low interest suggest that incentives may be beneficial to learning. (Cameron, 2001; Cameron & Pierce, 1994). Moreover, in video games, incentives are intrinsically tied to performance and are often a permanent aspect of the activity. In fact, game designers argue that incentives (either in the form of rewards or punishment) are essential to the fun or sometimes the compulsion of the experience (Fullerton, 2008; Koster, 2005; Schell, 2005). At best, an incentive can reverse the association between help-seeking and a perception of failure, signaling to the student that seeking feedback is a valuable act leading to proficiency.

Rubrics of Scoring Rules to Promote Clarity of Expectations

In formal learning settings, scoring rubrics (or codified scoring rules and corresponding score values) have been used to improve assessment clarity by making explicit what constitutes good performance. There have been numerous studies on teachers' use of rubrics, typically for student-constructed responses. Most of the research has examined how best to train teachers to effectively use rubrics to increase the reliability and validity of scoring performance assessments (Baker et al., 1995). Opportunities for student use of rubrics to improve learning appears logical, although only a few studies have examined this idea directly (Brown et al., 2004; Jonsson & Svingby, 2007; Sadler & Good, 2006).

When the scoring rules are appropriately tied to academic progress, providing an explanation of the game's scoring rules functions as a rubric in a game for learning. The scoring rules make explicit the stated learning objectives of the game as well as the criteria used to evaluate performance. The scoring rules can direct attention to what and how responses are being scored which may (a) make more explicit the learning objectives or goals of the game, (b) clarify the criteria of performance (i.e., what “counts”), and (c) support the development of selfassessment of performance to determine when additional help is necessary. This information can be provided prior to game play to guide performance, or as a context for elaborated feedback.

Summary

The literature review indicates that for learning environments to be effective, students need to use feedback in order to circumvent the ineffectiveness of trial-and-error learning. In this study, two aspects of design features were examined in game-based environments on math achievement, (a) incentivizing the use of feedback, and (b) different levels of making performance criteria explicit through the explanation of scoring rules.

Methodology

The following section will describe the research question addressed by the study, the research design, descriptions of the treatment conditions and dependent measures used in the study, and data analyses.

Research Questions

In a game designed to teach the addition of rational numbers:

1. What is the effect of providing an explanation about the scoring rules on (a) math achievement scores and (b) game performance?
2. Do incentives to seek additional feedback affect (a) math achievement scores and (b) game performance?
3. Does (a) lack of information or (b) providing an incentive affect the frequency with which students voluntarily access feedback?

Research Design

Data was collected from 112 students in fourth to sixth grades in after-school contexts. A randomized-control, 1 × 4 design was used in this study. There were four treatment conditions, which are described in the following section. Within participating after-school programs, each participant was randomly assigned to one of the four conditions.

Treatment Conditions. Table 1 contains descriptions of the four treatment conditions used in the study with regard to the amount of rules explanation and the incentive to use feedback.

Table 1

Description of Treatment Conditions Used in the Study

	Amount of information player was given regarding game's scoring rules				
Treatment condition	Explanation of scoring rules given prior to game play	Scoring explanations available in general help menu	Explicit feedback about when and how many points are earned and lost	Math elaborated feedback of scored event	After a mistake was made, player was given an incentive to access additional feedback help
No scoring information (*n* = 28)	O	O	O	O	O
Points-only feedback (*n* = 20)	O	O	X	O	O
Explanation of scoring rules (*n* = 22)	X	X	X	X	O
Rewarding help seeking (*n* = 28)	X	X	X	X	X

Experimental Materials: *Save Patch.* The game used in the study targeted two key mathematics ideas: (a) only identical units can be added to create a single numerical sum, and (b) the size of a rational number is relative to how one whole unit is defined.

The objective of the game was to help the game character (Patch) jump over obstacles (e.g., spikes, lava, quicksand) and move from block to block to reach the last –X” block (the final goal). In order to fulfill these objectives, students needed to compute the distance of the jump, place trampolines on the blocks, and add enough coils to the trampolines to make Patch bounce. The size of the coil determined how far Patch would bounce. For example, a one-half unit coil would cause Patch to jump over a one-half unit interval.

The first part of the game required the student to determine the size of the intervals of the grid. The intersection of vertical red bars indicated the boundaries of the whole unit. The green dots broke up the whole unit into intervals (see Figure 1).

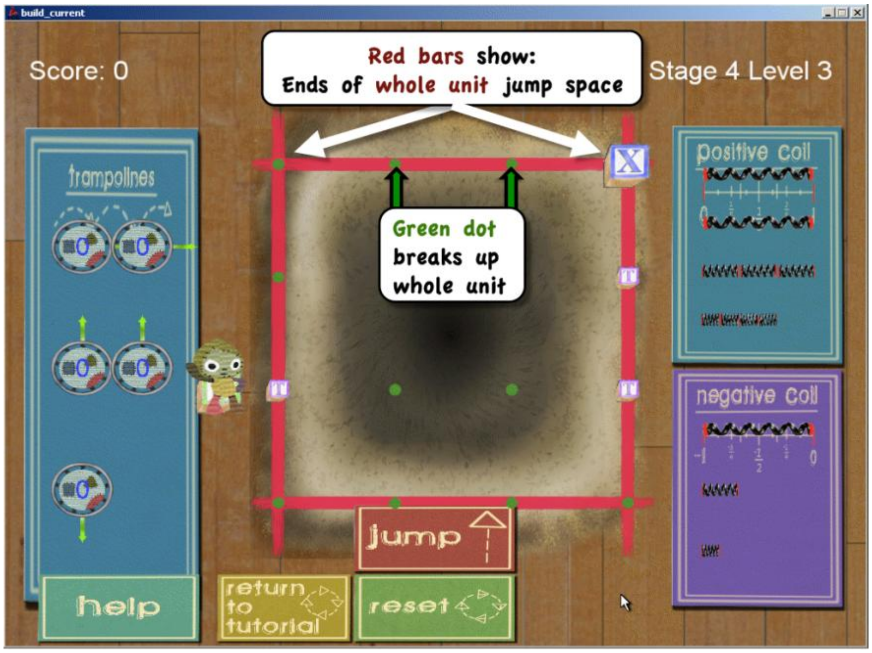

Figure 1. The intersection of the vertical bars depicted the boundaries of the whole unit. The green dots broke up the whole unit into intervals.

Once the students figured out the unit size of the spaces on the grid, they had to add together the correct number of coils that will span the distance to jump over. For example, in Figure 2, to get safely from one block to the next, Patch needs to jump over three one-third-unit intervals. This means that to successfully make it to the next block, the trampoline must contain three one-third-unit-sized coils. If the trampolines did not contain the correct number or size of coils necessary to get Patch to the next block, Patch exploded into feathers and the students were allowed to replay the level. To reinforce the idea that only fractions with like denominators can be added together, the student could not combine coils that have different unit sizes. If a student had a trampoline with a one-third coil on it and tried to add a one-sixth coil, the one-sixth coil would not go onto the trampoline.

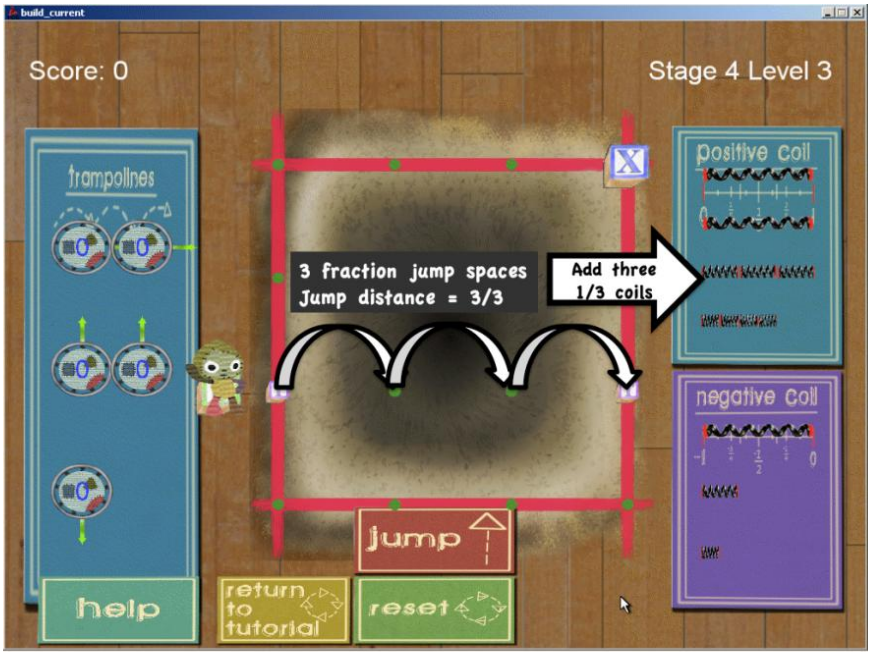

Figure 2. Jump distance equals total number of spaces between blocks. The number of coils to add to a trampoline equals the jump distance.

Save Patch Instructional Features

Tutorials. The tutorial design was meant to first contextualize the math concept within the game, and how the math concept relates to math in general. The tutorial information was presented in both written text and as guided interaction.

Scored events during game play. Across all of the conditions, three events were chosen as key points where performance would be evaluated because they mapped onto the learning objectives of the game. Points were earned any time the following event occurred: (a) student used coils that were the correct unit size for the grid, (b) student added together coils with like denominators, and (c) student successfully completed the level. Points were lost when any of the following events occurred: (a) student used coils that were not the correct unit size for the grid, (b) student attempted to add coils with unlike denominators together, and (c) student failed to get Patch to an intermediate goal.

Feedback. All of the players in each condition received feedback after three events. This feedback was in the form of the knowledge of results without elaboration or explanation. When a player tried to add a coil to a trampoline that had a coil with unlike denominators, the coils would not combine on the trampoline. Also, Patch exploded into feather when the trampoline had the wrong: (a) coil size and (b) amount of coils needed to cover the jump distance. When Patch jumped from block to block without exploding, this indicated that the player placed the correct quantity of coils needed to make the jump.

General help menu. All of the players in each condition had access to a general help menu at any time throughout the game levels. The topics that were included in the general help menu provided information on game mechanics (e.g., how to make Patch move in different directions) as well as instructional information such as how to choose the right-sized coil and how to add coils of different sizes.

Feedback help. After the second consecutive mistake, players in each condition were given an opportunity to access additional feedback by clicking on a button that read, ―Click here for help." The additional feedback provided elaborated explanations and hints that were designed to assist the player with repairing the mistake.

Procedures

An average of about 90 minutes was spent on the study at each site. The basic timing and order of the task were the same at each site. It took students about 10 to 15 minutes to complete the test, although the time necessary to complete the test never exceeded 15 minutes.

Every effort was made to ensure that each student played the game for at least 30 minutes. However, the amount of time for game play varied because many students departed for home early. Students who did not play the game for at least 20 minutes were dropped from the analyses.

After playing the game, the students were given the posttest and the demographic/motivation survey. Students were told that some of the questions that appeared on the pretest would be on the posttest, but that the information they learned from playing the game might be useful to answer the posttest questions.

Table 2

Description of Dependent Measures Used in the Study

Math achievement	Game performance	Total proportion of times additional feedback accessed
Pretest: 31 items Posttest: 44 items (includes items in game context)	Number of: coils added together (both common and unlike denominators) wrong-sized unit coils used resets failed attempts	Overall in the game After coils with different denominators were added together When a wrong-sized unit coil was used Failed attempt

Analyses

Pooling the Points-Only and No Scoring Rules Information Data

The purpose of pooling the data from the points-only and no scoring rules conditions was to create a condition that represented a minimal scoring information group. Two independent samples t-tests were computed to compare the groups on the math achievement measures to ensure they did not differ significantly. There were no significant differences between the two groups on the posttest, $t(48) = .58$, $p = .57$, transfer items, $t(48) = 1.19$, $p = .24$, or the game context item scores, $t(48) = 1.03$, $p = .31$. Therefore, for the purposes of testing the three hypotheses of the study, the data from students in the points-only and no scoring rules groups were pooled together and henceforth referred to as the minimal scoring information group. Three sets of orthogonal planned comparisons were conducted to examine if the data supported the hypotheses of the study.

Results[1] for Math Achievement

Table 3 contains a summary of results for the math achievement scores. For the overall sample, students who were given the explanation of the scoring rules plus the incentive had significantly higher normalized change scores, compared to students who were given minimal scoring information. better had the results indicated that compared to students who received minimal scoring information, students who were provided both explanation of the scoring rules and an incentive to seek additional feedback had significantly higher normalized gain scores on the math assessments ($d = .53$) and better game performance ($d = .99 – 1.09$), with stronger effects for students with low academic intrinsic motivation ($d = .88 – 1.17$).

[1] For an extended discussion of the results of the study, please see Delacruz (2011).

Table 3

Summary of Results for Math Achievement Scores

Sample of students	Posttest scores	Gamelike items	Normalized change scores
Overall sample	No group differences	For students with *low* prior knowledge, scores were higher for explanation of scoring rules + incentive group For students with *high* pretest scores, scores were higher for explanation of scoring rules group.	Minimal scoring < Explanation of scoring rules + incentive (d = .53)
Low self-efficacy	Minimal scoring information group < (a) Explanation of scoring rules *and* (b) Explanation of scoring rules + incentive (d = .88)	Highest for students in the explanation of scoring rules + incentive group (d = .65)	No group differences
Lower math self-concept	No group differences	Highest for students in the explanation of scoring rules + incentive group (d = .89)	No group differences
Lower preferences for cooperative learning	No group differences	Highest for students in the explanation of scoring rules + incentive group (d = .97)	No group differences
Males	No group differences	No group differences	Highest for students in the explanation of scoring rules + incentive group (d = .93)

Game performance. Students who were given the explanation of scoring rules plus the incentive added fewer coils with unlike denominators than the students in the other conditions (d = .61 – 88). Student who were given minimal scoring information had to reset the level more times and had more failed attempts than students in the other conditions (d = .99 – 1.09).

Results for voluntarily accessing feedback. Students given the incentive accessed the feedback less frequently and spent the least amount of time on the feedback screens than the other students. However, when feedback was accessed, compared to the other students, they would solve the game level more quickly and with fewer mistakes. Furthermore, upon the occurrence of the same mistake, students given the incentive sought additional information in the help menu on the same topic more often than students not receiving the incentive.

Conclusion

Overall, findings suggest that when designing games for learning, it is important both to make performance criteria (in this case, the scoring rules of a game) explicit to students and motivate students to use provided feedback through the use of incentives. There are two potential explanations for the positive effect of the combined incentive and explanation of rules. First, providing the rationale for the scoring rules may clarify the criteria of performance, (i.e., what ―counts”). Second, the incentive signals that the use of feedback is valuable and may increase the likelihood that students will engage in self-directed help-seeking and deeper engagement. Findings from this study suggest that it is important both to make assessment criteria explicit to students and to find ways to motivate students to use provided feedback through the use of incentives.

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