

5.5 The Impact of Incentivizing the Use of Feedback on Learning and Performance in Educational Videogames

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Abstract. Educational videogames can be designed to provide instructional feedback responsive to specific actions. However, existing research indicates that students tend to ignore the feedback provided. That is, students often use ineffective help-seeking strategies. Research on the topic of help-seeking in learning environments have 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 how to motivate the use provided feedback. This study examined the relation between incentivizing the use of feedback and providing an explanation of the game's scoring rules on math learning in a pre-algebra videogame. A randomized-control design was used, comparing learning outcomes of students who received the incentive with 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 ($d = .88 - 1.17$).

1.0 INTRODUCTION

When event data are used to evaluate performance and have consequential meaning for the student, feedback is usually given. As such, one affordance of games for learning is that they can be designed to provide instructional feedback responsive to specific actions. Germane to the discussion of student use of feedback is the research on help seeking. The type of help that is often used in help-seeking studies is tailored hints and feedback, or supporting information accessible in general help menus. 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 [1].

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 how to *motivate* students to engage effectively in help seeking and use provided feedback.

Moreover, this study is focused on learning games where game play is 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, game 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 will describe a study that examined the impact of both incentivizing the access of feedback and providing different degrees of explanation of the game's scoring rules on math learning and performance in an educational videogame that was designed to teach students about fractions.

1.1 The Importance of Feedback for Learning

Feedback related to progress in learning tasks can generally have a positive effect on learning [2]. There are certain conditions that make it effective—specifically, feedback should support clear understanding of the learning goals or objectives (and the criteria that define good quality), a way for students' to relate own performance to that goal, and then a indicate the path to achieve the goal if there is any discrepancy between the goal state and their own performance [3]-[5].

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 voluntarily available feedback. This is problematic as the lack of compliance with the treatment greatly reduces any potential effect on the outcomes. For example, Nelson [6] 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 [7] 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.

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

The use of incentives for seeking help and feedback provides a relevant avenue for exploration. That students avoid help seeking is not surprising given that historically, it has been discouraged in most learning contexts. Research conducted in classroom settings suggests that there is social stigma attached to help seeking, a public sign of failure [8]-[10]. Further, in game-based settings, accessing feedback slows the game down, and some games have speed of play as a basis of advancement. Moreover, in some technology-based environments, the access of feedback or available hints are associated with lesser proficiency or may be discouraged. For example, when a hint is given to a student in the PACT Geometry tutor, the student's visible "skill bar" decreases [11]. In games, students are often penalized when accessing help. In is discouraged (i.e., students are penalized 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 the communities that they are members of [12]-[13]. 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 [14]-[15]. 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 [16]-[18]. At best, an incentive can reverse the association between seeking help and failure, signaling to the student that seeking feedback is a valuable act leading to proficiency.

1.3 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 the teacher 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 [19]. Opportunities for student use of rubrics to improve learning appears logical, although only a few studies have examined this idea directly [20]-[22].

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 self-assessment 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.

1.4 Summary

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

2.0 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 the analyses of the data.

2.1 Research Question

In a game designed to teach the addition of rational numbers, are there differential effects on math achievement measures, game performance measures, and access of feedback help based on the amount of the use of an incentive to seek feedback and the amount of explanation of the scoring rules provided?

2.2 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

Table 1 contains descriptions of the four treatment conditions used in the study with regard to the amount of scoring rules

Table 1. Description of Treatment Conditions Used in the Study

Treatment condition	Amount of information player was given regarding game's scoring rules				After a mistake was made, player was given an incentive to access additional feedback help
	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	
No scoring information	○	○	○	○	○
Points-only feedback	○	○	X	○	○
Explanation of scoring rules	X	X	X	X	○
Rewarding help seeking	X	X	X	X	X

2.3.1 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). To do this, students

participant was randomly assigned to one of the four conditions.

2.3 Treatment Conditions

explanation that was provided and the incentive to use feedback.

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 have figured out the unit size of the spaces on the grid, they needed to add together the correct number of coils that will span the distance to jump over. For example, in Figure 3, 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.

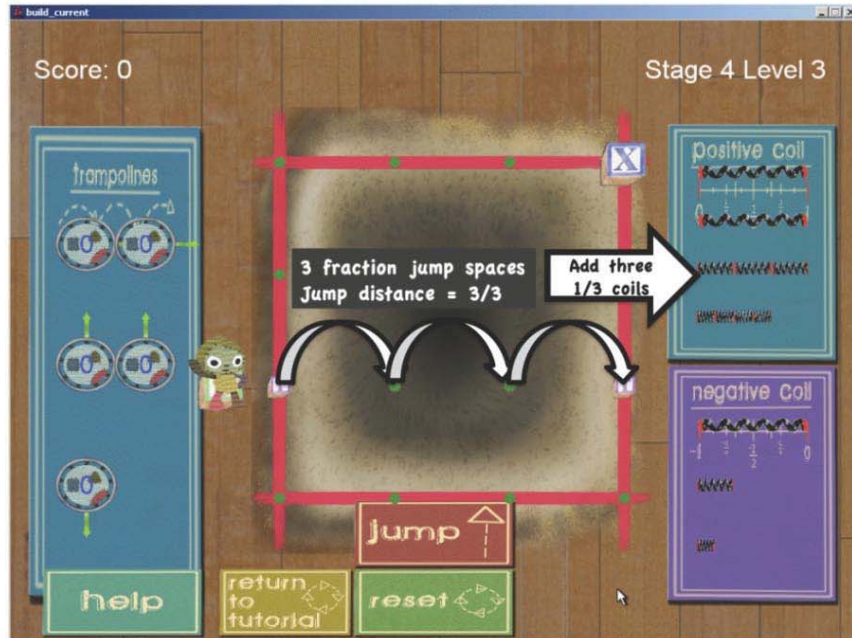


Figure 2. Jump distance equals total number of spaces between blocks. The number of coils to add to a trampoline equals the jump distance.

2.3.2 Save Patch Instructional Features

Tutorials: The design of the tutorial was meant to first contextualize the math concept within the game, and then discuss how that concept relates to math in general. The tutorial information was presented as both written text and 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, that 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, if the trampoline did not contain the correct-sized coil, or amount necessary to cover the distance of the jump, Patch exploded into feathers. 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, all of the 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.

2.4 Dependent Measures

Table 3. Description of dependent measures used in the study.

Math achievement	Game performance	Total proportion of times additional feedback was accessed
Pretest: 31 items Posttest: 44 items (includes items in game context)	Number of: - coils added together - 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

2.5 Analyses

Three sets of orthogonal planned comparisons were conducted to examine if the data supported the hypotheses of the study.

3.0 RESULTS

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 ($d = .88 - 1.17$). 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, unlike the students in the other condition, those given the incentive would seek additional information in the help menu on the same topic.

4.0 CONCLUSIONS

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 a student and to find ways to motivate students to use provided feedback through the use of incentives. There are two potential explanations of the positive effect of the combined incentive and explanation of scoring 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, increasing the likelihood that students will engage in self-directed help-seeking and deeper engagement with the information on the screen. 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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