Effective Practices in Game Tutorial Systems

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ABSTRACT

Efficient game tutorial systems are an essential part of educational games, providing targeted instruction to increase the player's proficiency in game mechanics while allowing more time for learning and game play. We have synthesized a system of effective practices for the design of educational game tutorials, and demonstrated their efficacy in a new tutorial system for an educational puzzle game called BeadLoom Game (BLG). When compared with a classroom introduction to the same material, students using the new tutorial system completed the tutorials in 75% less time while producing higher learning gains and higher levels of achievement. The practices devised and tested in our game tutorial system can be used to make educational games more scalable and effective.

Author Keywords

Educational games, game tutorial development

ACM Classification Keywords

K.3.1 [**Computers and Education**]: Computer Uses in Education – *computer-managed instruction (CMI).*

General Terms

Design, Human Factors, Standardization

INTRODUCTION

Game tutorial systems are an essential aspect of educational gaming software. The goal of educational games is to teach through the playing of the game [12]. Unlike in traditional tutoring systems where the goal is to provide mastery of the material through use of the system itself, a game tutorial only aims to familiarize the user with the goals and interface of the game. The mastery of the target learning objectives occurs through gameplay rather than completion of the tutorial. Therefore, it is necessary to minimize the amount of time needed to understand how to use the system. An efficient educational game tutorial increases proficiency in the game through integrated, targeted instruction on the system's features, while providing more time on task for learning and gameplay. Here we present a synthesis of effective practices for educational game tutorials, and experimental results showing the impact these practices can have on increasing time-on-task and promoting student learning.

BACKGROUND

An educational game tutorial needs to reveal basic concepts and the game interface while making it clear that advanced strategies exist, allowing the player to discover and learn the advanced strategies once they learn to play the game. In developing our educational game tutorial design, we considered two major issues: how to provide feedback to students, and what learning strategy to use.

Good Feedback

Well-timed, appropriate feedback is a particularly important way that intelligent tutoring systems adapt to individual students to support learning. Feedback can be considered as formative assessment - a way for a system to provide students indicators of their performance, in time for them to adjust the concepts they are learning and to keep them motivated. In their review of the literature, Nicol and Macfarlane-Dick synthesized seven principles in good feedback practice [15]:

1. Helps students understand good performance
2. Provides information that helps students self-correct
3. Provides opportunities for students to self-correct
4. Promotes self-assessment during learning
5. Praises effort and focuses on learning goals
6. Encourages dialog among teachers and peers
7. Helps (teachers) shape teaching

Timing can impact several of these features. Immediate feedback has been shown to increase learning efficiency by decreasing the amount of time spent to achieve similar learning gains to learning with delayed feedback [17]. However, delayed feedback can promote better self-regulated learning skills, such as error detection and self-correction [17, 8]. Immediate feedback can help students better understand good performance but does not necessarily promote self-regulation.

Nicol and Macfarlane-Dick's principles provide some guidance on feedback content - that it should be related to the learning goals and assessment, while also providing positive support. Cognitive feedback addresses the correctness of the knowledge, i.e. "That's right" or "That's incorrect, do this instead" [13]. This feedback is important to help students understand good performance, but purely corrective feedback decreases student motivation [10].

Affective feedback addresses emotions during learning, e.g. providing encouragement ("Good job") or preventing frustration ("Try again") [2]. Boyer et al performed a study across several peer tutoring sessions, tagging and classifying the dialogue actions of volunteer tutors. Interactions were tagged as cognitive or motivational, and classified as affectively positive or negative. They then analyzed both learning gains and self-efficacy gains of students who attended tutoring sessions with these tutors. Purely affective feedback (feedback containing only encouragement or minimization of failure) may make high self-efficacy gains more likely, but can decrease the likelihood of high learning gains. Positive cognitive feedback, however, combines positive affective support with a focus on how students can achieve the learning goals. Positive cognitive feedback was shown to increase students' perceived self-efficacy, and cognitive feedback in general was shown to promote learning gains [7]. Therefore, we propose that an effective tutorial system will make use of cognitive feedback, particularly positive cognitive feedback, wherever possible. We followed this guideline when designing our tutorial system.

Locus of control

One of the most significant decisions in tutorial design is the instructional "locus of control" - whether the student or the teacher or system controls the path and pace of instruction [11]. Fully guided learning, like a lecture, occurs when a system or instructor leads students through a task. In a free-play, fully constructivist learning environment, the learner is in control, choosing what to do, how to do it, and when, in an unguided process of discovery, trial and error. Each type has particular applications in different settings. In guided learning, we know that all learners have experienced the same content, but free-play allows students to explore and learn at their own pace. Research has made claims both for and against each side of this debate, but neither strategy is consistently effective for a wide range of students in a classroom setting [18]. With free-play learning, students with low understanding of the target concepts may not fully understand the choices available to them, leaving gaps in their knowledge. On the other hand, students who quickly grasp target concepts may be frustrated by guided learning strategies when they are presented with knowledge they already grasp or could have derived on their own. Students typically require more structure when their understanding of the topic being addressed is low or they're uncomfortable or unfamiliar with the content [9, 16]. Wouters, et. al suggest that novice users benefit from studying examples as they are worked, but more adept users may be frustrated by this experience; therefore they propose completion exercises, where a problem is partially worked through before being completed by the user [19]. Because our goal is to develop an effective game tutorial, we need a consistently effective learning strategy. Therefore, resolving the struggle between guided learning and free-play learning became the focus of our research

Gaming the System

"Gaming the system" can be defined as "attempting to succeed in a learning environment by exploiting properties of the system rather than by learning the material" [4]. This behavior, most often achieved through abuse of feedback, commonly includes quickly and repeatedly asking for help and systematically inputting answers without thinking about the solution [3]. As expected, gaming the system has been shown to be detrimental to learning [3]. Educational systems must balance teaching how to succeed without encouraging avoidance of learning material. Tutorial systems are particularly vulnerable to gaming, since they provide scaffolding and specific feedback on how to accomplish tasks. A successful tutorial system must prevent or discourage these behaviors to ensure that players attain a reasonable understanding of the game's goals and interface.

EFFECTIVE PRACTICES

We have synthesized the research to design, implement, and refine effective practices to support efficient learning in an educational game. We combine principles for good feedback and build our system to change the locus of instructional control in the following practices for a tutorial system:

1. Immediate, positive cognitive feedback that combines corrective and affective support
2. Short bursts of just-in-time instruction with visual cues and minimal text
3. Step-by-step scaffolds that fade into free play over the course of the exercise

These practices came about through the evolution of the tutorial system we created for BeadLoom Game. In this paper, we introduce BeadLoom Game, the iterations of the BeadLoom Game tutorial system, and how these iterations led to and support these practices.

BEADLOOM GAME

The Virtual Bead Loom [csdt.rpi.edu], the educational system that inspired BeadLoom Game, is a constructivist learning environment designed to teach Cartesian coordinates and geometry to middle school students.

BeadLoom Game, [community.game2learn.com], is an educational puzzle game that still enables creativity while providing feedback and incentives for students to focus on particular learning goals, including layering and iteration. BLG challenges players to recreate a target goal image on a 41x41 Cartesian grid in the fewest moves possible. A move draws beads using one of the six graphing tools: Point, Line, Rectangle, Triangle, Linear Iteration, and Triangle Iteration. Point plots a single bead, while Line, Rectangle, and Triangle plot multiple beads in a single move to form geometric shapes. Linear Iteration and Triangle Iteration tools create complex patterns using repetition. Figures 1-2 show the interface of the BeadLoom Game for drawing points (Figure 1) and linear iterations (Figure 2). When a student finishes a puzzle they are awarded a medal based on their performance: platinum for the best solution, gold for solutions using up to 1.5 times the number of moves of the best solution, silver for up to twice the best number of moves, or bronze for just completing them.

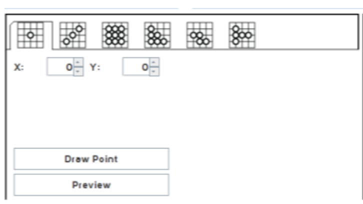

Figure 1: BeadLoom Graphing Tool for Point Function

Although any goal image could be created using just Points, players must use more complex tools to achieve higher scores. The game permits exclusive use of simple tools, and this is particularly helpful for novice players just learning to plot points. However, the game encourages a transition to using the more complex tools through performance medals and high score tables to rank the players.

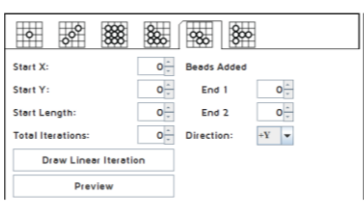

Figure 2: BeadLoom Graphing Tool for Linear Iteration

Linear Iteration and Triangular Iteration are the two most complex game "moves", where students control nested iterative loops to draw patterns. Figure 2 shows the interface where students enter a starting point, the starting row's length, how many rows to draw, in what direction, and how to modify the rows as the iteration progresses. For example, to draw the blue shape in Figure 3, students use the linear iteration tool with start point (-10, -10), start row length 5, 5 total iterations, 1 bead added to the right and (-1) beads added to the left each iteration, and finally set the direction to +Y to indicate growth upward. This is much more involved than simply entering x and y coordinates to draw a point, as shown in Figure 1, or entering two points to draw a rectangle

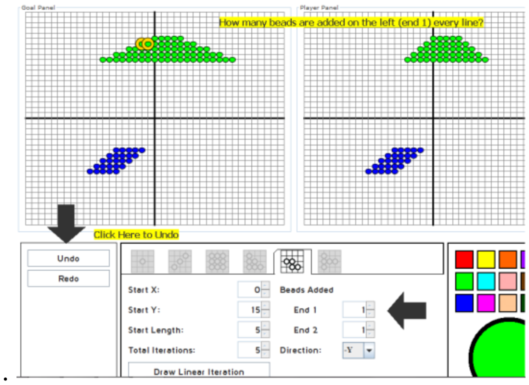

Figure 3: Linear Iteration Puzzle

In order for students to learn from BLG, they must first understand the basics of the game and how to use each graphing tool. Like with many educational games and tools, we needed a tutorial to provide this crucial information, especially for online play. In developing a game tutorial, we investigated effective practices for efficient learning of the game and its user interface, the type of feedback to provide, and the locus of instructional control.

EVOLUTION OF BLG TUTORIAL

Stage One: Free-Play Only

The BLG was originally designed to allow players freedom to choose their own puzzles to solve from a menu of puzzles. Therefore, the first tutorial system was created by adding six new tutorial puzzles, named for and specifically designed to illustrate how to use each tool. For example, the Linear Iteration puzzle, shown in Figure 3, was named after the tool that should be used to complete it. No instructions were given to indicate or require students to complete the new tutorial puzzles.

In this free-play style, students learn how to play by trial and error, feedback from the medal system, or asking the instructor or fellow students. However, when BLG was used in a middle school after-school program, students did not use the tutorials. Instead, students continued to use simple tools for more complex puzzles (like using points to make a line) and asked the instructor for help on iterative tools and which points to use for a rectangle. A post-survey showed that students learned the intended content, but were confused about elements of the game mechanics and interface such as if order of points mattered for drawing shapes and how to earn specific medals[5].

Even though students did not use the tutorials there are several features of BLG that promote learning. BLG provides immediate feedback by allowing players to hover over parts of the target puzzle to learn more about it, and the medal system provides delayed feedback on how each submitted solution could be improved. In addition, BLG's separate medal levels give an indication of just how much improvement could be made, either by using more complex tools or by working the puzzle faster. These levels discourage systematic guess-and-check, one common form of gaming the system. We kept these successful elements in later tutorial versions, but students still needed more guidance on how to play the game.

Stage Two: "How to Play" Section

To provide more instruction on how to play and use each tool, we added a new "How to Play" page to the game website and menu, providing the basic goals of the game and how to use each tool. These instructions were used for the first two days of a middle school math summer camp. At the beginning of the camp students were shown how to access the how to play section. Based on the number of questions the group was having we stopped the session and asked who had read the how to play section. A vast majority reported they had not read the section or only skimmed it. This reflects similar results to those by Alkan and Kursat, who used eye tracking methods to show that users preferred to learn how to play computer games by trial and error, or by asking friends how to play. Users spent the least amount of time looking at the menu, and they did not read the hints provided, even though they clicked on the hint button [1]. This research explains why most modern games only provide instruction within the game. Once it was clear that students were not reading the how to play section we stopped the session and transitioned to a new tutorial system where the instructor lead students through basic elements of the game as a group.

Stage Three: Guided Play Only

In this stage, we changed to guided learning, with instructor-led guidance through each of the six tutorial puzzles as a class. However, this approach was not particularly effective for individual learners. Some students grasped the material quickly and were bored waiting for others to catch up, while others needed much more time. This problem was particularly amplified when some students missed a step or fell behind, and became disengaged for the rest of the guided instruction. Later, these students would call the instructor over afterward, asking them to repeat the material. Although this was repetitive, it was manageable in an hour with a classroom of 20 students. But this solution doesn't scale: BLG is meant to be played online, and also meant to provide (non-BLG expert) teachers, with limited class time, a way to add learning content to their classes.

Stage Four: New Tutorial System

To address the issues of scale and individualized instruction, we built an in-game tutorial system, augmenting the initial six tool puzzles and a seventh Layering puzzle with in-game guided instruction. The new Layering Tutorial Puzzle, shown in Figure 4, helps students learn how to layer shapes to make complex patterns with fewer moves. Students can solve this puzzle by layering three rectangles from back to front (orange, blue, and cyan). Without layering, students often use nine rectangles to make this pattern. The medal system motivated students to try to improve, but didn't teach them what or how they could achieve that improvement.

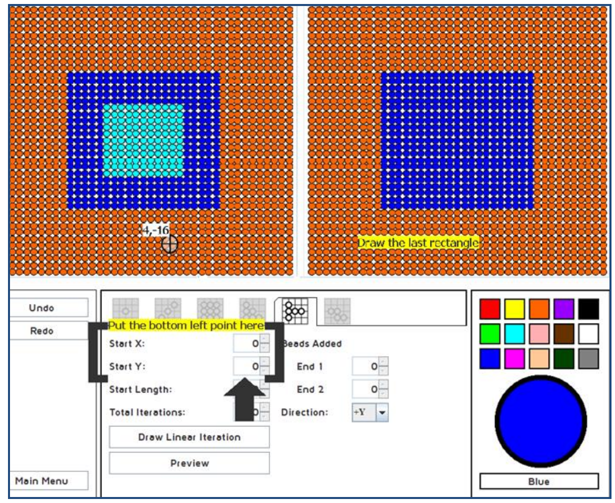

Figure 4: Layering Tutorial showing instructions

BLG now requires players to solve all the tutorial puzzles to unlock additional game content. The first half of each tutorial puzzle is guided, and then the system prompts the players to complete the puzzle on their own. For example, the Linear Iteration tutorial, (Figure 3), guides students through the steps to create the blue shape, and then asks students to create the green shape independently. The guided instructions combine short bursts of minimal text and obvious visual cues to direct students how to complete the next task. For example, the Layering tutorial instructions shown in Figure 4 use bold brackets and a large gray-black arrow to show students where they need to enter information. During the guided and free-play portions, the tutorial system provides immediate, individualized hints when students make mistakes.

Tutorial Design Choices

In designing each tutorial exercise, we strove to display feedback to motivate and direct players while being difficult to dismiss or ignore, provide just-in-time teaching through interactive worked examples, and guide players from system to student control.

We strove to implement immediate contextualized feedback, focusing on positive cognitive feedback when possible. Positive cognitive feedback (including statements such as "Correct" or "Yes, but try this instead") encourages students to continue without falsely increasing their self-efficacy. Negative statements like "No, that's wrong" may discourage students without providing enough direction to correct mistakes. Using positive cognitive feedback ensures students receive the cognitive “right or wrong” feedback necessary for learning, but also receive motivation to continue the learning process [7]. Feedback should also be individualized for each student and provided as immediately as possible after a mistake is made. BLG’s tutorial system accomplished this through immediate feedback to the player identifying that they have made a mistake, where the mistake has occurred, and suggestions on how to fix it. As an example, the Linear Iteration tutorial (Figure 3), begins by highlighting a single blue bead on the goal grid, placing brackets around the Start X and Start Y fields, and displaying a message (in yellow text) asking students to enter the location of the highlighted bead. After a student enters the correct coordinates, the player receives a brief positive cognitive feedback message, indicating their correctness. Then, the next instruction is given. When a player enters incorrect values, the game provides affectively neutral contextualized feedback addressing that specific mistake. In Figure 3, the player has incorrectly drawn the green iterative shape. The system prompts, “How many beads are added on the left (End 1) every line?”

We also developed the system to provide tutorial information using prominent visual cues rather than large amounts of text. Providing short bursts of information with minimal text is an efficient way to show students how to use the game interface while also preventing students from skipping through the tutorial without reading or attempting a solution. By making the information short we accomplish “segmenting” and “eliminate information redundancy” as described by Mayer and Moreno in their work on reducing cognitive load in multimedia learning [14]. Strong visual cues such as highlights or arrows that show where things are located in the user interface reduce the amount of text needed while directing student attention. This prevents the problem of students losing motivation while reading large amounts of text, or skipping over textual instructions and follows Mayer and Moreno’s method of “aligning” [14]. In Figure 3, as the tutorial dialogue is displayed, several important visual cues are drawn. The tutorial system highlights the incorrectly matched beads and displays large arrows at the bottom pointing to the “End1” field as well as the green goal shape, drawing the user’s attention to the area that needs review. From this information, the player can undo their mistake and enter the correct value into the “End1” field of the linear iteration tool. We also lock all graphing tools except the one involved in the particular tutorial to “eliminate interesting but extraneous material” also known as “weeding” [14].

Finally, in order to achieve the greatest learning gains for a wide range of students, the guided learning strategy and the free-play learning strategy must be combined. For each step, the student should be guided through the basics, and then given the opportunity to continue learning without strict guidance (free play). We used this strategy by providing step-by-step instructions at the start of each tutorial puzzle, then prompting the student to complete the puzzle on their own with instructions, with feedback only provided if the player makes a mistake. This results in the locus of control moving from the program to the player as less mistakes are made, granting novice users the guidance they need while providing more adept users with relatively uninterrupted free play.

In a more traditional tutoring environment, this level of feedback would be highly exploitable and could result in users “gaming the system”. However, the scoring system present in BLG discourages many common forms of “gaming” behaviors. Since the system only provides feedback after a mistake is made, as opposed to a hint button available at any point during the game, the player cannot effectively ask repeated questions without lowering their score. Similarly, if the player attempts to systematically guess rather than think the puzzle through, they will inevitably receive a poorer score.

METHODS

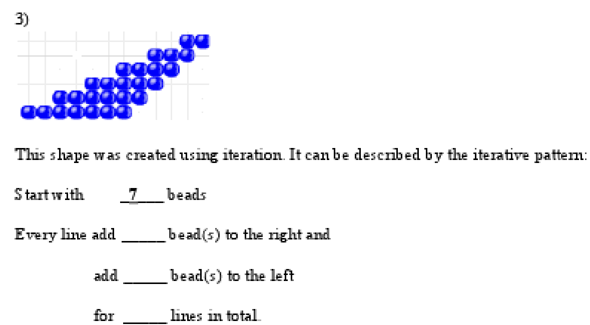

Figure 5: Sample Iteration Question

The new tutorial system was tested in a user study during a 2012 middle school summer camp with seventeen students, ages 9-13, with 11 boys and 6 girls. Students took a pretest on Cartesian coordinates, iteration, and layering, that was also used for prior studies on BLG [6]. Students created BLG accounts and were given one hour to complete the tutorial system, and were allowed to explore other puzzles if they completed the tutorials early. Later in the camp, students played BLG for an additional 30 minutes, for a total of 1.5 hours of BLG tutorial time and play. At the end of the summer camp, students took an isomorphic posttest. Sample test questions included asking how to create the iterative shape in Figure 5 and determine the minimum number of rectangles needed to make the American flag in Figure 6 (eight rectangles).

Additional comparative analysis was conducted using data from a previous study which used the stage three instructor-guided tutorial. That study was conducted in a 2011 summer camp that used the same schedule and tests as the 2012 summer camp. Thus the two groups (tutorial-guided

2012 and instructor-guided 2011) had equal exposure to the game and differed on the type of tutorial they were exposed to. The instructor-guided group featured 18 middle school students: 12 male and 6 female [6].

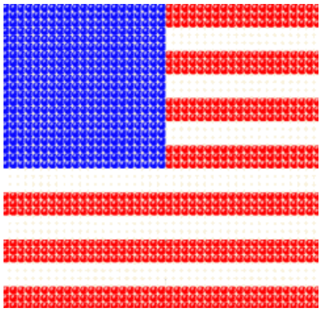

Figure 6: Sample Question that tests layering knowledge

RESULTS

We analyzed the data from our pre and posttest scores. Students performed significantly better, $t(16) = 8.47$, $p < .001$, $d = .90$, on the post test (*M = 7.18, SD = 2.93)* than on the pretest *(M =4.71, SD = 2.55).* Cohen's *d* indicates that students improved from pretest to posttest by **.90** of a standard deviation (see Figure 7). It is also important to note that every student showed some improvement from pre to post test.

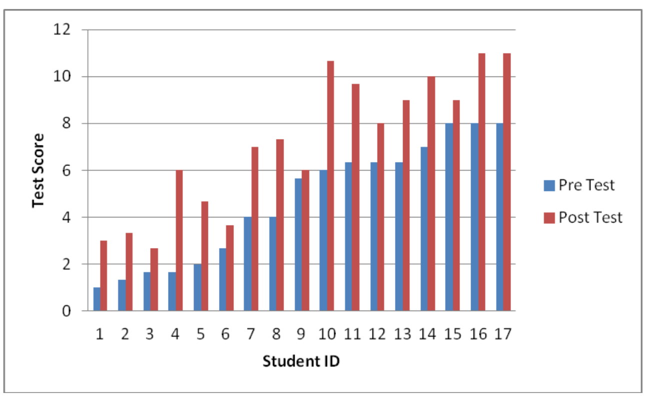

Figure 7: Pre and Post Test Data

Additionally, the time required to complete the tutorials was much lower than in stage three of our tutorial design. Stage three took an average of one hour for an instructor to lead the class through the tutorials. With the new tutorial, the average completion time was 14 minutes and 57.4 seconds (see Figure 8). It is important to note that this time is much less, even though it included 7 puzzles instead of 6.

We compared the total medal count for the tutorial puzzles for the instructor-guided 2011 and the tutorial-guided 2012 groups (Table 1). On the two most challenging tutorials about iterative tools, the instructor-led 2011 group had platinum medals on only 8.33% of the total medals earned while the tutorial-guided 2012 group had platinum medals on 55.88% of the total medals earned. During testing, a bug in our scoring system caused students to be falsely informed that they had earned a Platinum medal, despite completing the puzzle with a sub-optimal score. Despite this bug students in Stage 4 still understood the goal of finishing the puzzle in the fewest moves, but in some cases thought they were doing better than they actually were. Table 1 shows the correct medal totals earned by students. We believe further testing with this software with this bug removed would yield even higher Platinum counts as players would receive accurate feedback on their performance and be driven to truly achieve Platinum. Despite the bug, this shows that the new tutorial system fosters better game performance. This higher Platinum medal count also indicates that the tutorial-guided system minimizes gaming the system since students are finding the optimal solutions and not just guessing and checking.

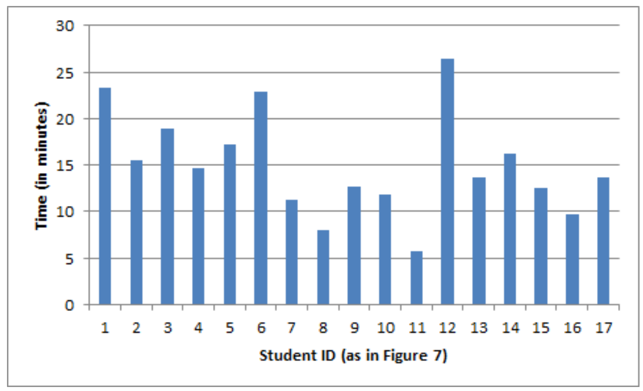

Figure 8: Average Tutorial Completion Time

Table 1: Average Tutorial Medal Count Per User

	Tutorial-Guided Group	Instructor-Guided Group
Bronze	.41	.11
Silver	.47	.17
Gold	1.24	.17
Platinum	3.88	2.38

Comparing the pre to post-test learning gains using the new tutorial system with the learning gains for the Summer 2011 instructor-led group shows improved learning in the same amount of time in BLG. The instructor-led group had an average pretest score of 4.18 [6] and the tutorial system group had an average pretest score of 4.71. The instructor-led group had an average post test score of 5.69 [6] and the tutorial system group had an average post test score of 7.18. While the instructor-led group difference was statistically significant and illustrated the educational potential of the BLG it is a far smaller change (1.51) than the change we found with the new tutorial system (2.42). This illustrates that not only does the new tutorial system result in better in-game performance; it also results in better mastery of the desired learning outcomes.

Students were encouraged to raise their hands and ask questions both while working through the tutorials and during the free play session afterwards. Although there were very few questions asked during the tutorial, some students raised their hands and asked how medals were assigned during the free play section. While medals are awarded for all the tutorials, the information about how medals are awarded is not directly stated in tutorials 2 through 7. Instead, this is displayed in a pop-up window at the completion of tutorial 1. This was the only information given to the user in a pop-up window. We conducted an informal survey of the group asking anyone who understood how the medal system worked to raise their hand. Only one student raised their hand. While the students understood the goal of solving the puzzles in the fewest moves possible, the exact cut off score for each medal presented in the pop up message was not understood by a majority of the students.

CONCLUSIONS

This paper describes the evolution of a tutoring system that teaches players how to play the BLG educational game, resulting in drastically improved tutorial puzzle completion times, while increasing the quality of the puzzle solutions. Based on how the tutorial for BeadLoom Game has evolved over several iterations, and on our evaluation of the changes we have made, we have developed the following set of guidelines that we believe are essential for developing strong tutorials for educational game software. In order for a tutorial to be effective, it should provide **immediate positive cognitive feedback that combines corrective and affective support, short bursts of just-in-time instruction with minimal text and prominent visual cues,** and **step-by-step scaffolds that fade into free play over the course of the exercise**. Although many of the practices we present here are synthesized from prior work on intelligent tutors, they have been applied not to the learning content of this educational game, but to learning how to play this game. As a result, students needed less time, and almost no guidance in learning to play, and could spend more of their very limited time on learning and exploring the game's intended educational content.

We recommend that other educational game developers consider the effective practices we have applied here when designing introductory tutorials to teach game play. Scaffolding learning with guided instruction followed by free play increased learning for both high and low performing students. Providing immediate, individualized positive cognitive feedback enables students to learn at their own pace while accomplishing a common learning goal. Giving just-in-time instructions in short bursts with visual cues, and unlocking successively challenging content as students play, ensure students grasp the game mechanics and interface, increasing the learning efficiency of the educational game.

We have demonstrated that our adaptations of effective Intelligent Tutoring System practices for a game tutorial system resulted in a tutorial system that is more effective than pure guided or pure free play, while overcoming the challenges specific to game environments. This allows the tutorial to introduce the game mechanics quickly and efficiently while allowing a majority of the learning to occur while playing and exploring the game environment. This is critical for educational games that are optional extracurricular activities, where players can choose to abandon the game at any time. These practices allow for scaling of educational games to a much broader audience and will make it easier for educators to adopt educational games in classroom and extracurricular settings.

Future Work

We would like to redesign the layering tutorial for a future user study. While layering scores did significantly improve from pre to post test, observations during the experiment showed that this concept was one of the more common areas of confusion. This could be because the layering tutorial contained a smaller free-play learning step than the other tutorial puzzles. This further suggests the importance of the free-play step in the learning process. The new layering tutorial will allow us to further investigate where the line between free play and guidance lies for educational gaming software.

Although the tutorial and game itself are designed to minimize "gaming" behaviors (repeated guessing, repeated hints, and so on) through the implementation of game mechanics, we would like to run a full study looking at what impact these game elements have on discouraging players from "gaming the system." While the pre to post test scores suggest that gaming of the tutorial system was kept to a minimum, a future study looking at student behaviors (as defined in [3]) when using a version with and a version without the medal system is necessary in order to make any substantive claims about this technique's efficacy . It may be that providing game elements like the medal system within other tutorials could help reduce these problem behaviors, not only for educational games, but also for tutoring systems in general.

During the study, we found that students in general did not have a complete understanding of the game's scoring system, despite this information being presented during the tutorial Since students did display understanding of other information presented during that tutorial, we hypothesize that students did not fully understand the medal rating system because the relevant information was displayed in a pop-up window, which players could rapidly close without reading or simply ignore. To investigate the effect different methods of presenting text has on the efficacy of our tutorials, we would like to evaluate multiple versions of the game, with and without information presented as pop-up windows. We believe that presenting information in this way is an ineffective strategy, and that users are more likely to ignore information presented in a pop-up than information presented through other on-screen indicators.

Finally, we would like to test the motivational effects of requiring the ideal solution for tutorial completion, rather than simply allowing any correct solution. Requiring players to find optimal solutions may lead them towards discovering advanced strategies sooner, but could frustrate players who are already having trouble grasping the basic concepts. We would be interested in seeing if this more guided implementation would result in higher learning, or simply frustrate novice players. It is clear that a combination of free play and guidance is ideal, but we hope to further understand where the optimal dividing line rests for BLG and learn what this may mean for other educational game software.

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