BeadLoom Game

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ABSTRACT

BeadLoom Game is an educational puzzle game designed to teach Cartesian coordinates, iteration, optimization, and the painter's algorithm. It features 35 puzzles for different skill levels as well as over 575 puzzles made by middle school and high school players. BeadLoom game has been the focus of many game studies including work on deep gamification, creativity in user-generated content, and effective practices for educational game tutorial systems. It represents rigorous educational game research, a successful introduction to important mathematics and computer science principles, and a fun and challenging experience even for college level players.

Categories and Subject Descriptors

K.3.2 [**Computers and education**]: Computer and information science education. – computer science education.

General Terms

Design, Human Factors

Keywords

Game development, gamificiation, education, motivation

1. GAME OVERVIEW

BeadLoom Game (community.game2learn.com) is an educational puzzle game designed to teach Cartesian coordinates and basic geometry as well as the important computer science principles of iteration, optimization, and the painter's algorithm. In the game, players are given a blank 41x41 Cartesian grid. Players have access to six different functions with which to plot colored beads onto the grid. The Point Function plots a single bead at a given point. The Line Function plots a line of beads between two end points. The Rectangle and Triangle Functions plot a rectangle or triangle of beads between two or three points. The final functions utilize iteration to create complex patterns in a single call. Each function is applied as a layer covering up beads beneath it.

The goal of BeadLoom Game is to recreate a given goal image in the fewest functions, or "moves", possible. While it is possible to recreate any image using a series of point functions this would result in a very poor score. In order to find the ideal solution, and earn a platinum medal, players must master the iterative functions and use clever layering. For example, it is faster and more efficient to begin most puzzles by drawing the background first. The game features 35 original puzzles which range in difficulty from easy (designed to feature basic principles ideal for middle school students) to hard (requiring mastery of iteration and layering; challenging even for college students). Each puzzle features a leaderboard that tracks all the players' best move counts and fastest times.

In addition to this main game BLG also has a custom puzzle creation mode where players can make their own original puzzles. Here players are given a blank 41x41 grid and tasked with creating the coolest and most challenging puzzle they can. In this mode each function is assigned a point value: Point 5 points, Line 4 points, Rectangle 3 points, Triangle 2 points, and Iterative functions 1 point. When the player is done with their masterpiece they can submit their work to a showcase. Showcases are divided up by total points: general showcase, 75 point and under, 50 point and under, and 25 point and under. Players can view the showcases and rank each puzzle on a one to five scale. The showcase is displayed in order of user ratings so in order to reach the top of the prestigious 25-point showcase players must not only create amazing pieces of artwork but do so in clever and efficient ways, using less than 25 points. In addition to seeing the puzzles in the showcase players can play them within the game. BeadLoom Game currently features over 575 user generated puzzles each with its own highscore board to conquer. This combination of creation and puzzle solving ensures that there are always fresh challenges and fun to be had.

BeadLoom Game also features a comprehensive tutorial system designed to walk players through the game but leaving the mastering of learning objectives to the game itself.

2. RESEARCH

BeadLoom Game began life as the Virtual Bead Loom (VBL), developed by Ron Eglash at RPI [6]. This tool featured the same six bead-plotting functions but none of BLG's game elements including goals, scoring, leaderboards, and user generated content. VBL was found to be effective at teaching the basic principles of Cartesian coordinates, however since there was no internal motivation to explore and use the more advanced concepts like iteration, players often defaulted to using the simpler functions and avoided learning the more complex concepts. In order to solve this problem, we developed BeadLoom Game. Our hypothesis was that, by augmenting the game with game elements such as points and objectives, we could provide internal motivation for players to use and master the iterative tools. In our first study using the game we found

that the BLG did indeed teach Cartesian coordinates as well as the more advanced concepts such as iteration and layering [1].

In our follow up study we compared the learning gains of VBL and BLG using a switching replications experimental design. In other words, half the participants played with the VBL then the BLG and half played with the BLG and then the VBL. Tests on Cartesian coordinates were given before the first software, after second, and at the end. Here we found that the BLG had the same impact on Cartesian coordinate learning but provided higher learning gains in the areas of iteration and layering. Thus through the addition of simple game mechanics we were able to motivate users and provide a measurable increase in learning gains [2]. These observations have driven us to study the process of converting educational tools into more effective and motivating educational games.

Based on the user feedback from the first two studies we noticed a trend. While a majority of players reported preferring the BLG some participants said they preferred the VBL citing its creative freedom. These more creative students did not like having to recreate the provided goal images and instead wanted to make their own unique designs. To accommodate these players we added a simple Custom Puzzle mode and the Custom Puzzle Showcase. This simple custom puzzle mode did not feature the points per function of our final design and instead allowed the player to use any number of functions in creating their design. All submissions were made to the one custom puzzle showcase.

We also saw that the more competitive players were comparing scores with their friends. When one friend beat their score they would replay a puzzle in order to get a better score. To encourage this behavior, and make it easier to compare scores we added leaderboards for every puzzle. We believed the combination of custom puzzles and leaderboards would increase the number of users who preferred the BLG to the VBL. To test this hypothesis we ran a study where we presented participants with different versions of the BLG. First, all participants were given the VBL and then we presented half the users with the BLG with leaderboards and half the users with the BLG with the custom puzzle contest. Finally we presented all the users with the full game. We found that although the addition of each feature did increase the number of users who preferred the BLG each feature was strongly liked or disliked by certain users. Those that reported liking creative freedom liked the leaderboards less and those that liked the competition liked the custom puzzles less. It was not until we provided the version with both features that we were able to obtain the maximum motivation from the broadest range of students [3]. This highlights the importance of providing play modes for both creative and competitive students in order to reach the most students with an educational game.

Additional work was done on the custom puzzle mode and the creation of user generated content. While the original custom puzzle mode did motivate the more creative users to create very complex designs analysis of the log files revealed that a majority of users were using the simple functions, like point and rectangle, when making their designs. This would not be a big problem except that some users were only using the custom puzzle mode. These users were missing the educational content the game was attempting to teach. We therefore developed the new custom puzzle mode and created a series of design principles for the creation of user generated content environments which can teach the user while they create. In order to evaluate these design principles and the new mode we first developed a mixed-fidelity prototype and tested to see if users would be motivated by the limitations to use the more complex functions. Our initial prototype results revealed that this mode did increase the number of iterations used per puzzle created. A follow up study was performed with the completed software in which we assessed the custom puzzle modes ability to generate learning gains in a classroom setting. Here we found that this mode did result in increased iteration usage as well as significant learning gains in the areas of Cartesian coordinates, iteration, and layering [5]. In addition to looking maximizing motivation and learning in the user generated content mode we also investigated the impact this mode had on the creativity and complexity of user generated content. We found that the user generated content mode and the limitations it presents resulted in students making significantly more creative and more complex designs then when allowed to create content in a completely free-play environment [5].

Our work with BeadLoom Game has led us to develop what we like to call "deep gamification." This process aims to go beyond the "shallow gamification" practice of only adding points and leaderboards in order to turn something into a game. It also looks a specific game elements and the impact they have on the motivation and learning gains of different types of players. Deep gamification consists of:

- Learning objectives integrated with game objectives
- No lose condition with levels of success
- Competitive elements such as leaderboards
- Social user generated content

These four elements combine to create a gamification system that maximizes learning and motivation for the widest selection of different types of players. The optional modes of engagement it represents is also the key to encouraging play with the game.

Our latest work with BeadLoom Game has been the development of a comprehensive tutorial system for players. This tutorial system is designed to teach players the UI and game objectives in an efficient manor while leaving the learning gains to be learned from exploration of the game space. We found that compared to classroom introduction of the same material, students using this tutorial system completed tutorials in 75% less time while producing higher learning gains and higher levels of achievement [7]. We designed and implemented our tutorial system using a series of best practices for effective game tutorial systems. The details of our study and these best practices are the subject of our submission to this year's FDG.

We feel that BeadLoom Game and the research done with it is an example of how all educational games research should be conducted. Equally important we have seen that the game is fun and challenging even for college level players like those that will be attending FDG.

3. TECHNICAL REQUIREMENTS

An internet enabled device capable of running Java. We will also bring business cards with the sites url to enable players to enjoy the game at their own pace on their personal machines.

4. LINK

community.game2learn.com

Sign up for an account to track your progress and high scores

5. ACKNOWLEDGMENTS

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