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A Practice and Evaluation of Game-based Learning Environment for Linear Equation

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Abstract: The purpose of this study is to design and develop a game-based learning environment (GBLE) that incorporates an educational control method to generates and enhance interaction among learners intentionally. In this paper, we explain a GBLE "Who becomes the king in the country of mathematics?", in which we incorporated "learner support agent" to support each learner and "game control agent" to control the game.

Keywords: Game-based learning environment (GBLE), Interaction among students, motivation, Pedagogical agents, Junior high school

Introduction

Many studies and systems to use "pleasure" and "fun" to be inherent in the game for improvement of the learner's motivation have been developed in the field of the learning environment [1, 3, 5]. However, when plural learners gather in one computer and learn by game-based learning environment (GBLE), there are still few studies, in which a computer designs the learning process by controlling the interaction (competition, collaboration and learning by teaching etc.) between learners and the observation (observational learning etc.) of other learners [2]. Therefore, the purpose of this study is to propose a method (interaction control between learners) to generate interaction between learners intentionally to create an opportunity of the learning depending on the situation of the knowledge understanding model of the individual learner. To achieve this purpose, we set up three sub-goals. Firstly, we try to propose the design of a GBLE that incorporates some viewpoints for the fun of the game. Secondly, we try to propose an educational control mechanism that creates a learning opportunity for learners in GBLE. Furthermore, we implement this learning environment with an agent system.

In this paper, we describe a GBLE "Who becomes the king in the country of mathematics?". And then, we explain the framework of educational control in this GBLE.

1. Outline of "Who becomes the king in the country of mathematics?" game

Users of games have classified this "fun" of a game differently. Koster has stated four propositions with regard to the fun of games [4]. Based on these propositions, we classified fun in an education game into the following four types (**Fun when a player achieves a goal**, **Fun when a player has an unpredictable experience**, **Elation when a player faces a challenging problem**, **Satisfaction when a player receives an honor**). It is effective for the maintenance and the improvement of a learner's motivation to develop the support that

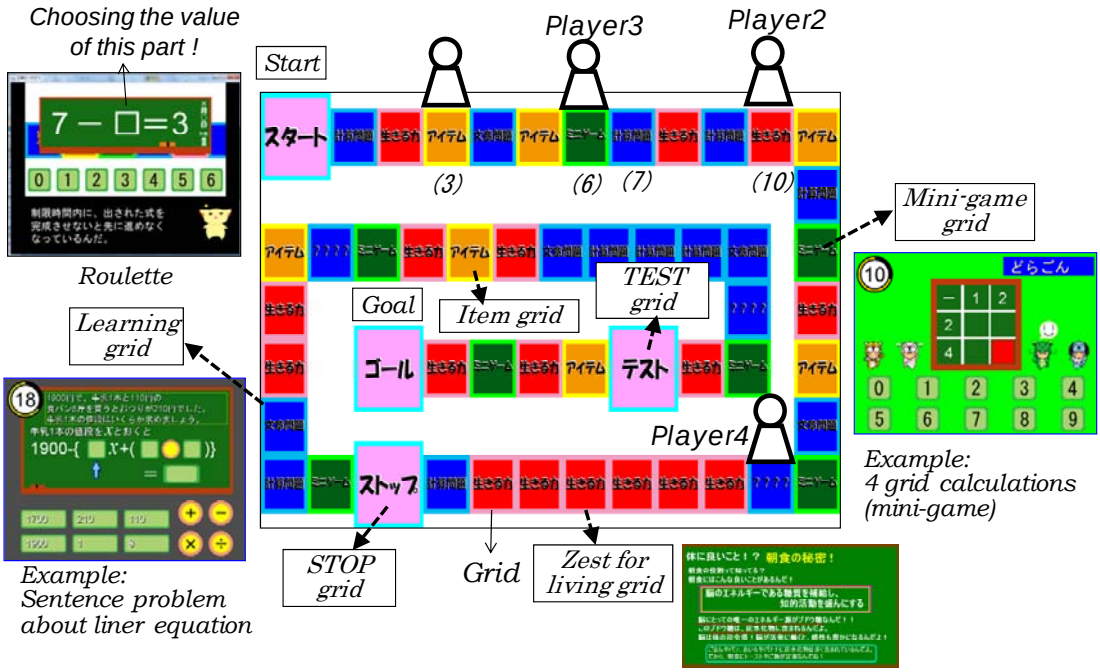

Figure 1. Image of game-based learning environment for linear equation

fun brings to the game in GBLE. Therefore, we set three design indicators in consideration of the four types;

I. Setting a time limit and the number of problems.
II. Preventing a player from getting tired by having to prepare too much for a questions form for a problem.
III. Setting a bonus point and various posts according to order.

We made a learning design in the GBLE based on the three indicators explained above. This game is a board game with roulette in which there are four players (see Figure 1). The winner can become the next king of the mathematics kingdom.

From the roulette, the player receives a number to determine his forward movement. He then replies with an unknown value in solving a calculating formula in the roulette. If the player solves the problem correctly, he can advance only the number of the answer. Next, the player carries out an event, such as the game or learning, on the grid on which he stopped. The player can increase the mark of a parameter (the learning power and the power of zest for living) of the organism which the player operates by clearing the event.

The player who has the highest general marks ([learning power] x [power of zest for living] + [bonus point]) becomes the winner when all players have reached the goal grid. At the end of the game, the first place player becomes the king of the mathematics kingdom. The second, third, and fourth place players are given a post depending on their general marks and the marks of two parameters for each player.

As different kinds of grids in this GBLE, there are a "Learning grid," a "Zest for living grid," an "Item grid," a "Mini-game grid," and a "Special gird" (see Figure 1). The "Learning grid" has to do with solving a problem about the linear equation for the subject domain. We prepared five learning items about the linear equation in this environment. A calculation problem or sentence problem is set to each grid. When a player stops on a learning grid, a learning form depending on his learning situation is set to the grid. The "Zest for living grid" concerns solving a problem about intellectual, physical and moral competency. When a player stops on a "Zest for living grid," a story about a problem that is chosen depending on the experience situation of the player's learning forms occurs, and the problem is shown (for

example, a problem about a moral or dietary education). The player must solve the problem by a method which computer points out. The "Item grid" is given by an item card which allows the player to advance only according to a number written on the card. The player can use the item card after his next turn. The "Mini-game grid" is about learning ability or the zest competency for living. The player carries the game such as "4 grid calculations" or "let's go out with me" either alone or while he competes or collaborates with other players. On the "Special grid" the player must stop forcibly. There are a "STOP grid" and a "TEST grid" as special grids in the developed game environment. On the STOP grid, the player plays rock-paper-scissors with the computer. If he loses, then he must play rock-paper-scissors again on his next turn. In addition, when the player wins, a bonus point is given at random. On the TEST grid, the player must answer all the questions for each learning item correctly. If he makes a mistake, then he must return to a certain grid.

2. Method for educational control in the GBLE

The learning control in this GBLE is performed by two kinds of agents (a "learner support agent" and a "game control agent"). The learning support agent diagnoses the state of understanding of the learner for which the agent takes care and has the role of determining an effective learning task based on his diagnosis. This agent recognizes the state of understanding of the learner for each learning item.

The learner support agent demands the learning item from the game control agent after determining the learning item of the learner. The game control agent receives information about the player's state of understanding and requests the next learning item from each learning support agent; he determines the learning item for the learner for his next turn and carries out the turn. When the learner needs learning control, the agent decides on a calculating formula and the answer by controlling the roulette. The agent has three learning forms; personal learning in which the learner himself solves a learning problem, collaborative learning in which the learner competes or collaborates with other learners, and observation learning in which the learner learns from other learners' problem solutions. The agent chooses a learning form based on the state of the learner's understanding for his next turn and for other learners.

3. Conclusion

In this paper, we described the design ideas of the GBLE that incorporated four viewpoints of the fun in the game and the outline of our game. Moreover, we explain the framework of this GBLE. In future, we would like to develop collaborative support protocols among pedagogical agents to support collaborative group learning as our final aim of this study.

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