A Design Principle and Collaborative Learning Support Method in Game-based Learning Environment

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Abstract: The purpose of this study is to propose a design principle and framework of educational control (in particular, method for collaborative learning support) that induces and activates interaction between learners intentionally to create a learning opportunity that is based on the knowledge understanding model of each learner. In this paper, we explain the design philosophy and the framework of our game-based learning environment (GBLE) called "Who becomes the king in the country of mathematics?". In addition, we describe the method of collaborative learning support control that incorporates a "learner support agent" to support each learner and a "game control agent" to control the game into the learning environment.

Keywords: game-based learning environment, design principle, framework of educational control method, collaborative learning support method, pedagogical agent

Introduction

Many researches of education system which utilized a computer game effectively have been pushed forward [2, 3, 8, 9, 11]. Not only the study on motivational factors which a computer game has [7], but also the study on combining learning contents with game-based learning [5] effectively has been performed in this research field. Moreover, given recent progress in network (in particular, wireless), mobile and interface technologies, various types of game-based learning environment begin to be studied.

On the other hand, the research on CSCL in which the computer supports collaborative learning activity by plural learners is pushed forward [9, 12]. It is thought that the game-based learning environment incorporating the function of the computer game for collaborative learning and group learning becomes one of the effective learning environments. In these game-based learning environments, we need the following functions; for examples, a learner modeling function and a learning support function for an individual learner, a learning flow building function and a collaborative learning support for a group. We can propose a computer-supported collaborative learning environment which activates not only the interaction among learners but also the interaction among learning supporters and learners by designing and implementing these functions as pedagogical agents [1, 4, 10].

Therefore, the purpose of this study is to propose a framework of educational control that induces and activates interaction between learners intentionally to create a learning

opportunity that is based on the knowledge understanding model of each learner. In this paper, we explain the design philosophy and the framework of our game-based learning environment (GBLE) called "Who becomes the king in the country of mathematics?". Moreover, we describe the method of collaborative learning support control that incorporates a "learner support agent" to support each learner and a "game control agent" to control the game into the learning environment.

1. Design principles in GBLE

The game developer and the expert about the game have been performing the various classifications and definitions about "the fun of a game" [6, 7]. Koster considers the game as a learning process which solves the given game task and skill by trial and error, and tries to solve the framework of "the fun of a game" from a viewpoint of cognitive formation of a game player [6]. He has stated that the four tasks that must be mastered exist in the learning process, and "the fun of a game" arises in the mastery process and success experience of these tasks [6]. Moreover, Malone proposed the following individual motivational factors; Appropriate challenge, Emotional fantasy, Cognitive and sensory curiosity [7].

Based on these classifications and definitions, we classified the fun which a learner feels in an educational game into the following four types: *Fun when a player achieves a goal, Fun from what a player is unable to predict, Elation when a player faces a challenging problem, Honor for the player.* These four types of "fun" in an educational game lead to the maintenance and improvement of a learner's motivation, and we believe that they give a game and the learning from it advanced power. Therefore, in the design of a GBLE, it is important that we incorporate these four viewpoints of fun into the scenes or phases of the game and the learning that comes from it.

In a GBLE, it is effective for the maintenance and the improvement of a learner's motivation to develop the support which utilizes the fun which a learner feels in an educational game. In this research, we have examined the design principle of a board game based learning environment for schoolchildren and junior high school students. Therefore, we set some design principles based on the four types of fun, which the learner feels in the educational game, in the development of the educational game design and learning support function design in the GBLE. These designs principles are shown in Table 1.

We have created an educational game design in the GBLE based on these all design principles explained above [12]. Moreover, we have designed and implemented the function and mechanism of the learning support based on the design principle and the support elements referred to literature (including Koster's suggestion mentioned in this section) as an educational control described in section 2. In addition, we accept that the case where concrete design principles differ according to the difference in the subject domain and learning style of a GBLE exists. Examination of the design principle in a different game form and leaning style is future work

2. Method of educational control in GBLE

The game developed in this study is a board game with a roulette in which there are four players (learners). The winner can become the next king of the mathematics kingdom. From the roulette, the learner receives a number to determine her/his forward movement. She/he then replies by trying to solve a calculation formula in the roulette with an unknown value. If the learner solves the problem correctly, she/he can advance only by the number of the answer. Next, the learner carries out an event, such as learning or the game, on the grid on

Table 1: Design principles of "Who becomes the king in the country of mathematics?"

- *Fun when a player achieves a goal*
  [Principle1-1]
  Existence of various types of grids
  [Principle1-2]
  Setting a reward by clearing the given event (For example, "prize" or "increasing the mark of a parameter")
  [Principle1-3]
  Selection and question of a learning subject according to the situation of each learner
  [Principle1-4]
  Setting the number of problems according to the situation of each learner
  [Principle1-5]
  Setting a time limit of problems according to the situation of each learner
  [Principle1-6]
  Motivation for fun when a player achieves a goal
  [Principle1-7]
  Setting a collaborative and competitive learning style
- *Fun from what a player is unable to predict*
  [Principle2-1]
  Setting a grid in which a special event occurs
  [Principle2-2]
  Selection of net learning style (Such as by a time trial, or having to check answers for other players)
  [Principle2-3]
  Selection and question of new learning subject
- *Fun from what a player is unable to predict*
  [Principle3-1]
  Setting the increase in the number of problems
  [Principle3-2]
  Setting a problem to which the degree of difficulty becomes high
  [Principle3-3]
  Shortening the time limit of problem solving
  [Principle3-4]
  Setting a cost when a learner fails in a learning subject
  [Principle 3-5]
  Motivation for challenge
  [Principle 3-6]
  Setting a collaborative learning style
- *Honor for the player*
  [Principle4-1]
  Setting players' ranking at the time of ending
  [Principle4-2]
  Motivation for aiming at a championship

which she/he stopped. The learner can increase the mark of a parameter (the learning power and the power of zest for living) of the character (avatar) that the learner operates by clearing the event. There are several types of grid in this GBLE: a "Learning grid," a "Zest for living grid," an "Item grid," a "Mini-game grid," and a "Special grid". On the "Special grid", every learner must stop forcibly. There is a "STOP grid" and a "TEST grid", which are special grids in the developed game environment. On the "STOP grid", the learner plays rock-paper-scissors with the computer. If she/he wins, a bonus point is given at random. On the "TEST grid", the learner must answer all the questions for each learning item correctly. If she/he makes a mistake, then she/he must return to a certain grid specified by the computer. This game is a type of educational game. Therefore, we need to control the game educationally in order to activate the interaction between learners and to be able to acquire the desired knowledge and skill for learners.

We have studied the interaction among groups, the direct support for each learner, and lesson support for a teacher as the extension of this GBLE to support the group. In this environment, we need the system configuration using agent which can support each learner or group, and interact with other learning supporter flexibly. So, we have been developing the system with agent model. In this GBLE, the learning and educational control in this GBLE is performed by two kinds of learning support agents (one "Learner Support Agent" per learner and one "Game Control Agent" in GBLE) (see Figure 1) [12]. We have designed and implemented the function of the learning support in these learning support agents based

on the design principle of the fun which a learner feels in an educational game and learning support function described in section 1.

The support function of the learner based on [Principle 1-3, 1-6, 1-7, 2-2, 2-3, 3-2, 3-5, 3-6 and 4-1] is designed and implemented for the LSA("Learner Support Agent"). The LSA has three tasks: One is to determine the learning control type of the learner as a method for maintaining or improving the learning volition of the learner. The agent gives four questionnaires for a learner at random before starting a game. The learner replies with yes or no. Then, the agent tries to motivate the learner to increase the learner's learning volition appropriately. Moreover, the agent adds up the mark of four answered items and classifies it in three types (Controlling learner in the first half, Controlling learner in the latter half and No control) based on the total value.

The function of educational control in GCA("Game Control Agent") is implemented based on [Principle 1-2-1-5, 1-7, 2-2, 2-3, 3-1-3-4, 3-6 and 4-1]. The GCA performs an educational control of four players (learners) who play the game-based learning. This agent has the following global strategy: *The agent tries to check that the student has a value of more than US2 for all learning items until she /he reaches the TEST grid. The agent tries to make sure that the student stops all learning grids in which the value of the learning item is less than US1. The agent tries to ensure so that the learner can experience various learning forms in the game.*

Based on these strategies, the agent advances the game-based learning by using control rules such as questions, individual learning and group learning. Concretely, the agent receives information about the understanding state of learner and requests the next learning item from each learner support agent. The agent determines the learning item for the learner for her/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 means of 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 of the next turn and other learners' understanding.
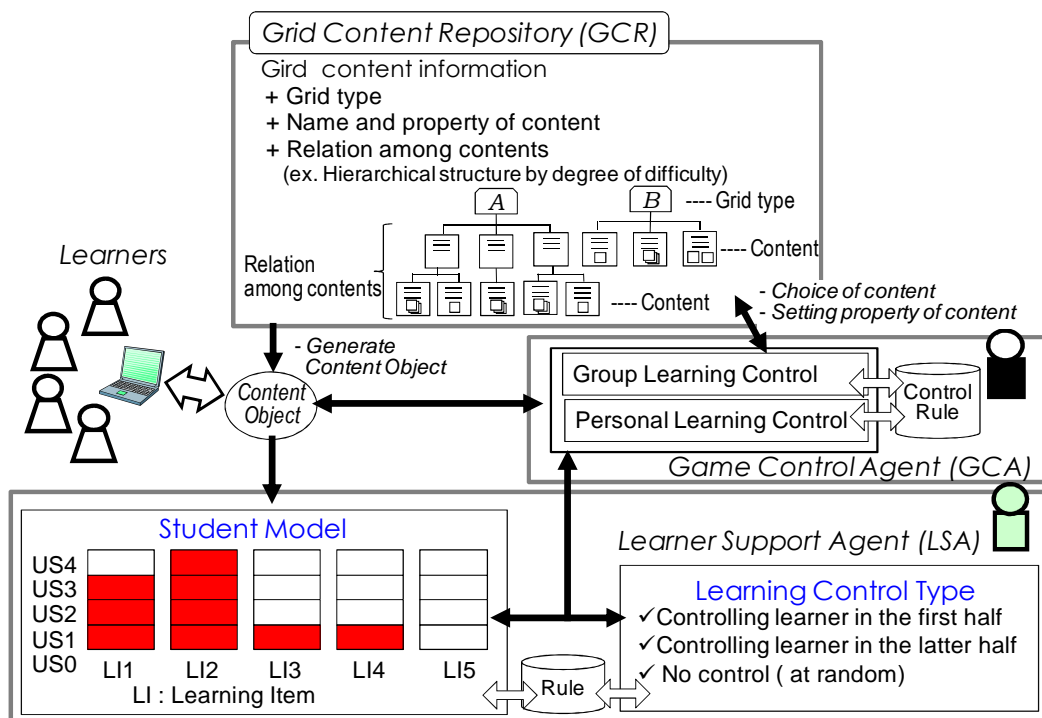
Figure 1: Task about learning and relation among GCR, LSA, GCA

Our system has the mechanism of the collaborative learning support. Furthermore, there are two interaction layers in the system. One is a "Learning Support Workplace (LSW)". The other is a "Learner Support Planning Workplace (LSPW)" to consider and decide the learning plan by interacting among agents. The flow of decide collaborative learning support decision making are as follows; Firstly, agents set the learning support goal, learning support method and, the member and the role of learning supporters. Moreover, they make a scenario of the collaborative learning support. Then, they move to LSW and start the scenario. If they can't achieve the learning support goal by the scenario, the challenge becomes the failure. Afterward, they return to the point (such as learning support goal setting process and learning support method setting process) of the factor.

3. Conclusion

In this paper, we explained the design philosophy and the framework of our game-based learning environment (GBLE) called "Who becomes the king in the country of mathematics?". In addition, we described the method of collaborative learning support control that incorporates a LSA to support each learner and a GCA to control the game into the learning environment. As further work in the future, we need to elaborate and rebuild the method of collaborative learning support control.

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