An Adaptive Learning Strategy Scheme for Role Playing Learning

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ABSTRACT

Traditionally, the assessment of the advanced knowledge about science such as problem solving or inquiry process is a challenging issue. In this paper, we aim to develop a Role Playing Learning platform called "The Banana Farm" to support the assessment of the nature science learning with collaborative fruit planting and marketing scenario. To support the assessment for inquiry process, our idea is to design the learning platform based on the multi-stage graph model in which the stages of vertices represent the student's actions and decision making during the assessment. Thus, the paths chosen to perform can be seemed as the science inquiry processes of them. Since the actions of the same stage may be executed several times, the model is extended to have self edge. Besides, the environmental status and the effectiveness of the learning objects are also extended by the working status and constraint rules in each stage. Thus, the extended Modified Multi-stage Graph (MMG) is proposed to support the assessment of inquiry process by the portfolio paths chosen in different stages. Next, the portfolio is collected for the collaborative behavior mining to discover the students' frequent collaborative action and interaction patterns during the learning. Combining with the characteristics of students, the assessment of teams with different learning strategy and behavior patterns can be obtained. Finally, the experiment on 40 junior high school students has been done and the findings were presented.

Keywords: role playing learning, game, e-Learning, assessment, data mining, multi-stage graph

1. INTRODUCTION

In the Scientific Literacy education domain, there are multiple knowledge dimensions such as science as inquiry, science content, science and technology, science in personal and social perspectives, history and nature of science, unifying concepts and processes, etc. [8]. Traditionally, the assessment of the knowledge about science is relied on the Paper-and-Pencil Test which is suitable for the primitive knowledge or comprehension level. However, the assessment for the advanced skills such as problem solving, inquiry, or social perspectives is a difficult issue.

With the growing of learning technologies, the Role Playing Learning (RPL), in which student takes the role of a person and experiences the impacts of the role with predefined situations, is usually applied to augment the curriculum and motivate real world skill learning. To enhance the learning impacts of the RPL, the game platforms or simulation system technologies were applied in several researches. In this paper, we aim to develop an RPL platform called "*The Banana Farm*" to support the assessment of the nature science learning with collaborative fruit planting and marketing scenario. However, in the RPL, it raises another technical issue of how to discover the behaviors or intentions of the students from the portfolio.

To solve issue above, our idea is to provide a collaborative learning platform with stages of scenario and predefined actions in each stage to reveal the collaborative problem solving or science inquiry processes of students. Thus, from a banana was planted and grown to harvest and sold, the behavior of students are modeled as sequence of decisions. Therefore, with the

designed win-win marketing strategy based upon a trade-off between individual profits or group profits, the assessment of the social perspectives can be possibly obtained from the way they collaborate to each other. With the designed disasters and *Return of Investment (ROI)* for planting of banana, the assessment of "science as inquiry" can be obtained from different reactions.

Accordingly, the **Staged RPL Scheme (SRS)** with **Modified Multi-stage Graph (MMG)** model is proposed to model the environment conditions and available actions in different time with different stages, and to model the available actions affected by the previous decisions with the edges between stages. Since the expertise of the environmental objects is usually inherited from stereotyped knowledge features, the frame knowledge representation with stereotype slots/values and event driven stored procedure is proposed to implement the environment.

To support the analysis of students' portfolio for adaptive learning, the **collaborative behavior mining algorithm** is proposed to discover the frequent sequence of decisions. The discovered behavior patterns can have meaningful interpretation with the MMG to reveal the possible learning strategy of students.

Finally the prototype system has been implemented and several experiments have been done. The experimental results and findings of different students' learning strategy and behavior patterns were presented.

2. RELATED WORKS

Role-Playing Learning Systems

In traditional RPL, student takes the role of a person and experiences the impacts of the role with predefined situations. It is helpful for learning [9][3]. With the growth of learning technology, e-RPL becomes popular gradually [7][6][10][11][5][2]. Also, the interest surrounding gaming in education has waxed and waned several times over recent years [1][2][4][12]. It is reasonable for student playing role in interactive game environment. [7] is a web-based role-playing simulation generator. It generates web-based role-playing scenario for student to use. In designers' point of view, they don't know students' intention when they see the web page. Otherwise, the student could link to other web pages without any intervention. [2] have mentioned that it is possible to use different web-based Interface for students with different cognitive style having their own learning preferences. But it still can't control what the student do or why do they see other web pages.

Game to Learning

In [10][11], they make a game named Farmtasia. The Farmtasia game encompass knowledge points from geography, biology, chemistry, technology and economics. An important feature of Farmtasia is that all players' actions and activities in the game are logged. This feature allows teacher to observe and understand students' progress and to extract interesting scenarios from the game proceedings as case studies for class discussion and reflection purposes. The multiplayer nature of the gaming platform ensures the composition of complex and often unique game scenarios as a result of collective behavior of all players. In [15], the "fish tank system" which is a simulation-based learning environment was proposed. This fish tank simulation is designed to model the nitrogen cycle in an aquarium. The model for the environment is adopting a multi-agents approach to building a simulation model where components of the underlying model can be inspected through exploration. Every thing in the tank has been defined previously.

Even though most of game like this can be used for education, most of them are entertainment-oriented or performance-oriented because of increasing learning satisfaction.

3. STAGED RPL SCHEME

To support the assessment of student's science inquiry, the **Staged RPL Scheme (SRS)** is proposed with three phases which are the Modified Multi-stage Graph modeling phase, the Frame-based Environment Implementation phase, and the Collaborative Behavior Assessment phase. In this paper, the subject of banana planting in nature science domain is implemented as the interactive learning platform called "*The Banana Farm*". The detailed descriptions of the platform are as follows.

Modified Multi-stage Graph model

In "*The Banana Farm*", the background learning scenarios are designed as follows.

- The farming scenario design for problem solving assessment

The first scenario design is farming strategy, which we want the student to realize "*the balance of soil status and market demand*". In our farm, soil status and marketing demand are two key points. The soil status would be infertile if growing too much. The marketing demand will increase if selling banana with high quality; otherwise, it will decrease. In general, the students may think of growing banana as more as possible. So, how to balance the soil status and marketing demand is a tradeoff. If the student could make this balance, it might create the win-win scenario together with the environment.

- The marketing scenario design for science inquiry assessment

The second scenario is marketing strategy, which we want the student to realize the brand-consciousness. In our market, the student may refer to the banana type, quality and market status to make a target decision. The high quality banana is much difficult to grow than lower, but with higher profit. The market brand will increase if selling high quality banana continually; otherwise it will decrease. If the student could make the balance between quality of banana and market brand, it might create the win-win scenario.

To represent the assessment scenario described above, the student's sequences of decisions are modeled as the Modified Multi-stage Graph (MMG). The definition of MMG is as follows.

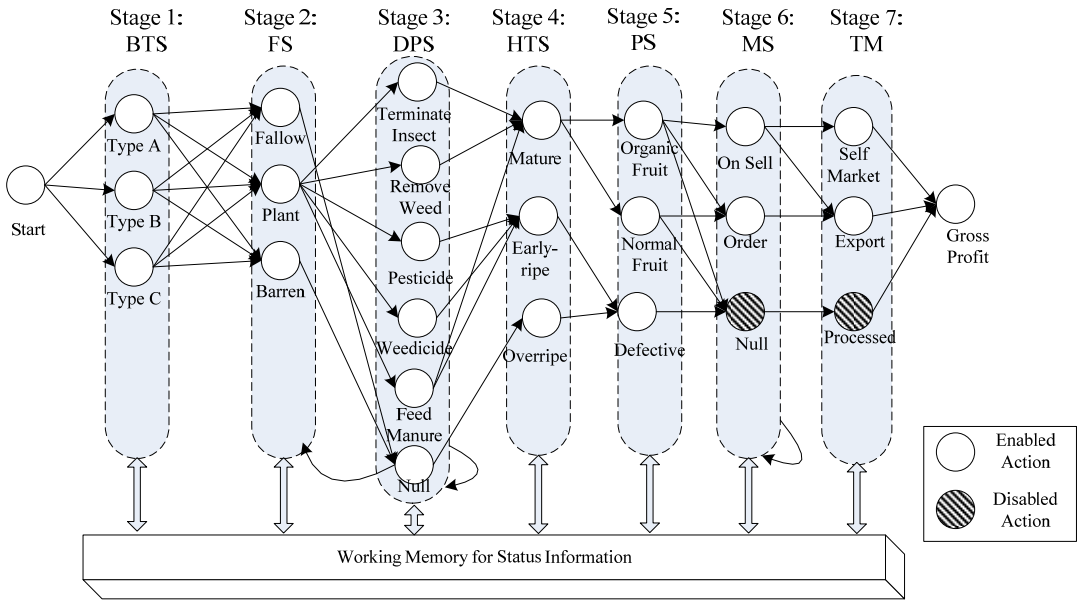

Figure 1. The seven stages MMG of the game "*the Banana Farm*"

Definition 1. The Modified Multi-stage Graph (MMG)
A modified multistage graph MMG=(V, E) is a directed graph in which the vertices are partitioned into k (k>1) disjoint sets V_i, $1 \le i \le k$

- E= (<u, v>, c, r) is an edge in E where vertices $u \in V_i$ and $v \in \{V_{i+1}, V_i\}$ for some i, $1 \le i \le k$; the action execution cost c where $0 \le c \le 1$, and the constraint rule r is with the format "*if <environment condition> then <enable or disable action v>*".
- The extra starting stage V_0 and finish stage V_{k+1} are such that $|V_0| = |V_{k+1}| = 1$
- Each set V_i defines a stage in the graph
- Extra working memory can be provided for each stage's status information.

Example 1. The MMG of the game *"the Banana Farm"*
As shown in Figure 1, there are seven stages in the game "*the Banana Farm*". In each stage, there are several predefined actions which can detect the meaningful behavior and inquiry process of students.

- Stage 1: Banana Types Selection (BTS)
- Stage 2: Field Sowing (FS)
- Stage 3: Disaster Problem Solving (DPS)
- Stage 4: Harvest Timing Selection (HTS)
- Stage 5: Product Selection (PS)
- Stage 6: Marketing Strategy (MS)
- Stage 7: Target Marketing (TM)

Frame-based Environment Implementation

Since the expertise of the environmental objects is usually inherited from stereotyped knowledge features, the frame knowledge representation with stereotype slots/values and event driven stored procedure is proposed to implement the environment. As shown in Table 1, there are five primitive types of frames for the status and action monitoring in the learning environment. In the staged RPL scheme, the MMG is implemented with frame representation.

As shown in Figure 2, the designed scenario of each stage is implemented by the disaster frame to generate worm event, weeding event, customer event as the testing for students. The students' actions of each stage are implemented by the configuring of attributes in action frames. Finally, the tracking of environmental status is implemented by the object frame and status frame.

Table 1. The frame representation for game objects

Frame type	Example	Description
Action frame	Marketing action, farming action	The actions that the students can perform to show their decisions in each stage.
Disaster frame	Insect event, weed event, customer event	The interaction events of environment for problem solving.
Object frame	Banana status	The attribute-based main object.
Status frame	User status, soil status, market status, partner status	The status information for the environment.

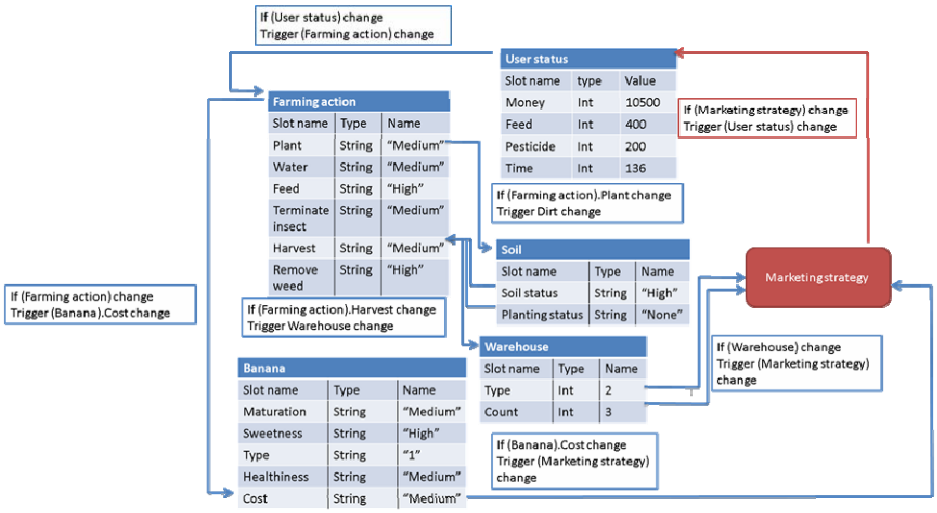

Figure 2. An example of farming scenario design using frame knowledge representation.

4. THE COLLABORATIVE BEHAVIOR ASSESSMENT

The students' learning characteristics [14] and sequence of decision making portfolio are considered in this research to describe the learning assessment of students. The thinking styles acquired by questionnaire are adopted as the students' learning characteristics. The students' learning characteristics and portfolio definitions are as follows.

Algorithm: Apriori Algorithm
Symbol Definition:
α: The minimum support threshold.
β: The minimum confidence threshold
Input: Sequence of Decisions(*SD*) of learner, Minimal Support (α)
mal frequent playing patterns (*MP*).
Step1: Find all frequent itemsets: Each of these itemset will occur at least α.
Step2: Generate strong association rules from the frequent itemsets: these rules must satisfy α and β.
Step3: output the *MP*

Definition 2. Student Characteristic C ∈ {E, L, J}

- Executive (*E*): Prefer to obey rules and deal with prefabricated questions.
- Legislative (*L*): Prefer to design their own approaches to handling issues and challenges.
- Judicial (*J*): Prefer to evaluate rules and deal with analytical questions.

Definition 3. The Portfolio of the Student S= (ID, C, P), where

- ID: denotes the unique identification of a student.
- C = <$c_1c_2…c_n$>: denotes the characteristic of the student.
- P = <$p_1p_2…p_n$>: denotes the path of actions performed with teammates on MMG during learning activity, where s_i is an item which means a legal decision.

For example, in Figure 1, if a student which is Executive thinking style chooses Type A in stage 1 and Plant in stage 2 and then Removes Weed in stage 3 and lastly Overripes in stage 4, denoting that the student can be represented as S = (*80601*, *E*, *<"Type A", "Plant", "Remove Weed", "Overripe" >*).

With the portfolio defined above, the behavior mining can be applied with Apriori Algorithm[13] to discover the frequent behavior patterns of the actions and interactions during the learning.

5. EXPERIMENT AND FINDING

System implementation

The "The Banana Farm" screen shot is shown below. In Figure 3, it is a banana farm. And in Figure 4, it is a banana market. The student could do farming actions (e.g. such as growing, insect removing, etc.) and selling actions (e.g. such as product choicing, selling, etc.) respectively.

Table 2. The frequent patterns of different team's portfolio

Team member Style	Planting (Stage 3, 4)	Harvest (Stage 4, 5)	Target Marketing (Stage 7)	Learning Result
Team with *L* and *E*: (*L*, *E*)	Lower defective rate	Organic, Defective, Overripe	Food Processing Market , Self-Market	Most teams can make money
Team with *E* and *E*: (*E*, *E*)	Higher defective rate	Organic, Early-ripe	Self-Market, Food Processing Market ,	Most teams can make money, but less then team style (*L*,*E*).
Team with *L* and *L*: (*L*, *L*)	Highest defective rate	Organic	Export	Most of the team lose money.



Figure 3. The screen shot of the banana farm



Figure 4. The screen shot of the banana market

Experiment results

In this experiment, the 40 junior high school students who participated the learning activity on "*The Banana Farm*" were divided into 20 groups, where some groups had similar characteristic and others had different characteristics. The experiment result is shown in Table 2. The discussion and findings of students in three types of team are as follows.

- **Team with characteristics (*L*,*E*):** Student who prefer an Legislative style is good at communicating, coupled with an Executive style student which is conscientious. The Legislative style student could express their ideas and the Executive style student could do things well. On the one hand, because of the Legislative style student always doing things on his/her own approach, some poor quality bananas sometimes will be planted. On the other hand, due to the Legislative style student full of creativity, they know that defective banana can sell to the Food Processing market in case of suffering brand values of other market.

- **Team with characteristics (*E*,*E*):** Two students both preferring Executive style collaborate together sometimes want to things perfect. All of them want to plant high quality bananas may bring to dead rate higher than (*L*, *E*). Nevertheless, they know selling high quality bananas to self-market for increasing brand value. They know selling poor quality ones to process market. However, they still earn less money than (*L*, *E*) because of anxious to be good. Especially, the first and the second moneymakers in our experiment are this type. It means that although two Executive style students may bring to high dead rate, they might still get the high quality bananas and make the highest brand value to earn much money.

- **Team with characteristics (*L*,*L*):** Two students both preferring Legislative style collaborate together sometimes want to do the things on his/her own way. But this always brings bananas to higher dead rate. Even they rarely could collect some high quality banana by ones' own. But finally they will be losing money because of lacking collaboration.

6. CONCLUSION

In this paper, the assessment model on Role Playing Learning platform called Staged RPL Scheme is proposed with the MMG modeling, frame-based environment implementation and the collaborative behavior mining. The proposed MMG extends the self-loop edge and the working memory of the environmental information to support the required process. Finally, the experiment results show several interesting behavior patterns of different characteristic students. In the future, mode assessment element can be included to perform more comprehensive assessment for students.

ACKNOWLEDGEMENT

This research was partially supported by National Science Council of Republic of China under the number of NSC95-2520-S009-007-MY3, NSC95-2520-S009-008-MY3, and NSC96-2522-S -009-002.

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