Designing a Trading Card Game
as Educational Reward System
to Improve Students' Learning Motivations

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Abstract. Reward is the simplest way to motivate students in education. It can encourage students to learn and get immediate achievement. Moreover, it is also has potential to construct students' intrinsic motivation. However, traditional rewards are often less valuable thus can't keep motivating students, e.g. symbolic rewards like stars or stickers can't be used by the students after the class; therefore, the values of symbolic rewards are not appreciated by the students. This research designs cards of a self-developed computerized trading card game (TCG) as educational rewards in order to inspire students learning, e.g. higher learning performance a student shows up, higher level cards the student would receive from the teacher. And of course, the student would have higher chances to beat other players in the TCG. Through the TCG, the rewards can hold students' interest for longer.

Keywords: Trading Card Game, Reward, Learning motivation, Competition, Game.

1 Introduction

Rewards are often used as praises by teachers when students behave well. Some researchers argue that reward is positive reinforcement that can improve students' learning motivation [7][14]. On the other hand, some others point out that the usage of rewards might cause negative effects [1][9]. Although the researchers have different opinions about the effect of rewards, rewards can provide short-term incentive immediately to intrinsic motivation [5]. Wu and Elliott (2008) have found that students have different preferences toward to rewards [15] and Winefield, Barnett and Tiggemann (1984) have showed that the reward contingency also affects the learning performance [2]. Teachers need to consider carefully while designing reward dispatching methods. Stars and stickers are widely used as educational rewards in schools. However, the symbolic meanings of the stars and stickers are intrinsically meaningless to students, e.g. the stars and stickers can't be used by the students to buy anything after

the school. Although McNinch (1997) chooses cash as reward and successfully stimulates students to read [7], it is also easily criticized by others as suborning. For these reasons, this research designs different level cards of a self-developed trading card game (TCG) as educational rewards to stimulate students' learning motivation. To students, the cards of the TCG can be collected and played anytime and anywhere after the class.

This research designs a TCG platform and its cards for making the educational rewards be valuable and appropriate to students. Section 2 discusses the game genres and the game-based learning definitions. The TCG elements are analyzed based on three famous commercial TCGs: "Magic: The gathering" [10], "Yu-Gi-Oh!" [22] and "Aquarian Age" [3] in Section 3. Section 4 designs a computerized TCG according to the analysis in Section 3. A prototype TCG is developed in Section 5. At the end, Section 6 gives a brief conclusion and describes possible future works.

2   Games and Learning

According to Vossen's research in 2004, three attributes are used to analyze game category, are competitive, interactive, and physical [6]. Table 1 lists six game subcategories. For example, card games like poker are categorized as an interactive non-physical game which has attributes: competitive, interactive, and non-physical.

Table 1. Game Categories according Vossen's research [6]

Game Subcategory	Competitive vs. Non-competitive	Interactive vs. Non-interactive	Physical vs. Non-physical
Non-competitive Non-physical Games	Non-competitive	Non-interactive	Non-physical
Parallel Non-physical Games	Competitive	Non-interactive	Non-physical
Interactive Non-physical Games	Competitive	Interactive	Non-physical
Non-competitive Sports	Non-competitive	Non-interactive	Physical
Parallel Sports	Competitive	Non-interactive	Physical
Interactive Sports	Competitive	Interactive	Physical

Trading Card Game is a kind of card games but is different from the poker or UNO. First of all, in general, TCGs have more cards than the poker and UNO, poker has only 56 cards and UNO has 108 cards whereas TCGs always have hundreds of cards. Second, cards in TCG are extendable, which means, we can design new cards when we need. Children and adolescents, including students, spend their leisure time on playing games [12]. The game features attract players are fantasy, curiosity, challenge and control [11]. Some researchers point out that playing can hold student attentions and make learning be more interesting [12][17]. For this reason, many studies use commercial games directly or design new education games and have evidences of students can get significant improvement in learning [12][13][16][20].

Besides, researchers point out that if the reward is worthless to student, the effect of motivation improvement will be no significant or even no effect [4][21]. Since the games attract students so much, this research considers using cards in TCG as educational

rewards; making the educational rewards become useful and playable to the students; and, aiming to implement a TCG environment on computers for students competing themselves with their classmates with the educational rewards, the different level cards, they have received from the teachers and/or online testing.

Interpersonal motivation is important in learning [18]. Malone and Lepper propose that competition is an approach to create interpersonal motivation [8][19]. For this purpose, this research uses the players' scores and ranks in the TCG to establish a competitive environment. By depleting opponent's cards, students can earn scores for rank promotion. The ranks can intrinsically motivate students. The way to deplete the opponent easier is to get higher level cards, and the students can get higher level cards by accomplishing the task/test their teacher(s) assign/give to them. The students can receive rarer cards from the teacher(s) according to their performance. Thus, the students will keep learning in order to have better performance to get higher level and rarer cards for defeating others and making them hold/get higher ranks among players.

3   TCG Environment Analysis

3.1   Game Flow Analysis

Most modern TCGs are turn-based. Each player acts after the previous player finished his/her actions. When all the players take their turns, the circle will restart again from the first player. The game will stop when one of the players achieved the game goal, e.g. reaching the specific scores or making all other players withdraw from the game. Three well-known TCGs, "Magic: The gathering", "Yu-Gi-Oh!", and "Aquarian Age", are analyzed to find the TCG model.

Because of the TCGs are turn-based, the game flow is the first issue to discuss. Table 2 analyzes the basic unit of the three TCGs. Each TCG has atom action. Taking "Magic: The Gathering" as example, the atom action is "step"; the set of the atom actions is "phase"; and, a player could have several phases before he/she claim him/her is done and the next player is allowed to do actions, the duration of a player's all phases form a "turn".

Table 2. Action analysis of game flow according to three commercial TCGs

	Magic: The Gathering	Yu-Gi-Oh!	Aquarian Age
Atom action	Step	Action	Action
Set of atom actions	Phase	Phase	Phase
The duration of a player's all phases	Turn	Turn	Turn

Based on Table 2, this research defines the TCG flow as five parts with a hierarchical relationship.

- Action: the atom action in TCGs, e.g. drawing a card or going to attack.
- Phase: a collection of atom actions.
- Turn: the duration from a player starts his/her actions to gives the token out to the next player.

- Round: the duration of all the players finished their turn once.
- Game: a set of rounds from the very beginning to someone reached the game goal.

Different TCGs have different definitions to the phases. Table 3 lists the three major phase categories and its definitions and explanations:

- Initial phase: this phase is the first phase of a turn. At this phase, most of TCGs only allow players drawing card(s) from a pack which is also called library or deck. For example, the beginning phase in "Magic: The Gathering" belongs to the initial phase.
- Main phase: this phase allows players doing actions to attack other players or defending himself/herself in the game. Players at this phase could also doing some strategic actions such like putting cards into the game field or using Tool/Magic Card to change other cards' attribute values.
- Final phase: this phase is the last phase of a turn. This phase assesses the player's status to make sure the resources the player currently has comply with the rules. For example, the end phase of "Magic: The Gathering" asks the player discarding the surplus cards if the player has cards on his/her hands more than the rule defined.

Table 3. Three major phase categories in different commercial TCGs

	Magic: The Gathering	**Yu-Gi-Oh!**	**Aquarian Age**
Initial Phase	Beginning Phase	Draw Phase, Stand Phase	Draw Phase, Influence Phase
Main Phase	First Main Phase, Combat Phase, Second Main Phase	Main Phase I, Battle Phase, Main Phase II	Main Phase Power Card Phase,
Final Phase	End Phase	End Phase	Discard Phase

3.2 Game Elements Analysis

After we analyzed the TCG flow, the elements of TCG environment are needed to discuss to help us developing a computerized TCG. This research considers three major TCG elements: player, game field, and card.

Table 4. The player attributes in TCG environment according to the three commercial games

	Magic: The Gathering	**Yu-Gi-Oh!**	**Aquarian Age**
Life Points	Lose, if life point drops to 0	Lose, if life point drops to 0	Lose, if accumulating damage over to 10
Remaining Cards	Lose, if runs out of cards		

Player
Players are defined as people who can do actions in the game. The player has several attributes for representing the player's status and being used to check whether the

player wins or loses. Life points and remaining cards are two attributes which have been widely used for this purpose. As Table 4 lists, two "lose" criteria in "Magic: The Gathering" are: (1) if a player's life point drops down to zero; (2) if a player is required to draw a card while there is no remaining cards in his/her deck.

Table 5. Four areas in the Game Field according to the three commercial TCGs

	Magic: The Gathering	**Yu-Gi-Oh!**	**Aquarian Age**
Cards in player's hand	Hand	Hand	Hand
Card set for player drawing	Library	Deck Zone, Extra Deck Zone	Deck
Used or destroyed cards	Graveyard	Graveyard	Graveyard, Damage Zone
Cards in using	In Play	Monster Card Zone, Spell & Trap Zone, Field Card Zone	Field

Game Field

Game field is the area players placing and manipulating cards during they play the game. Table 5 lists four major areas in the game field for different purposes: (1) for players to hold the cards; (2) for storing cards which have not been drawn yet; (3) for collecting the used, destroyed, and defeated cards; and, (4) for placing the cards to attack and/or defend include set traps. For example, the four areas in "Magic: The Gathering" are called (1) Hand; (2) Library; (3) Graveyard; and, (4) In Play.

Cards

Cards are the major tools for players to fight with each others. The cards can be clustered into three categories:

- Avatar Card: these cards can attack or defend for the players, just like soldiers fight according to commander's orders. To win a TCG, player needs to use Avatar Card to defeat opponent's Avatar Card. The creature cards in "Magic: The Gathering" belong to Avatar Card as Table 6 lists.
- Tool Card: these cards can change other cards' attribute values during the game and will be discarded when its duration is expired or when it is attacked by other players. The sorcery card, instant card, enchantment card and artifact card in "Magic: The Gathering" belong to Tool Card.
- Power Card: To restrict player's action in a turn, player usually needs to pay additional resources, the Power Cards, to take specific actions. Land Card in "Magic: The Gathering" belongs to Power Card.

3.3 Game Rules Analysis

Most of the rules in TCGs can be classified into four types. Figure 1 shows the idea of different rule types: "card ↔ card", "card ↔ game field", "card ↔ player", and "game field ↔ player".

Table 6. Three card categories of commercial TCGs

	Magic: The Gathering	**Yu-Gi-Oh!**	**Aquarian Age**
Avatar Card	Creature Card	Monster Card	Avatar Card, Break Card
Tool Card	Sorcery Card, Instant Card, Enchantment Card, Artifact Card	Spell Card, Trap Card	Permanent Card, Project Card, Fast Card
Power Card	Land Card	N/A	Cards with face-down

- Card ↔ Card: Cards in the game field would interact with each others, e.g. Avatar Card can attack other Avatar Card, and also, Tool Card can change Avatar Card's attribute values such as speed and attacking power.
- Card ↔ Game field: The card positions in the game field represent the card status, e.g. a card in the graveyard presents it had been destroyed or discarded.
- Card ↔ Player: If a player's Avatar Card is defeated by attacking, then the attack will cause damage to the player's attribute such as life points and may affect the game results, e.g. the player loses the game.
- Game field ↔ Player: If a player runs out of his/her cards in the deck/library, then the player loses the game.
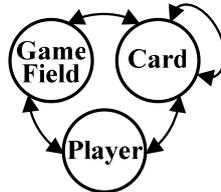

Fig. 1. Four different rules coming from the relations among the TCG elements

4   TCG Design

For constructing a computerized TCG environment as educational reward system, this research designs a TCG according to the analysis in the previous section.

4.1   Environment Design

The computerized TCG has three major parts, which are the cards, the game field, and the player schema.

Cards
According to Table 6, this research designs "Avatar Card", "Magic Card" and "Trap Card" for the computerized TCG. Table 7 shows that each card type's definition and effect, moreover, each card type has different attributes. For example, the attacking power is an attribute of Avatar Card and can be used to calculate the damage this card might cause to other Avatar Card during fighting.

Each card in this computerized TCG has "rank" attribute which is the card level. Using Avatar Card to attack is the major way to defeat opponent's Avatar Card. When an Avatar Card is defeated, the player's life points will be taken based on the avatar card's "size" attribute. The larger avatar will cause the player larger damage when it is defeated. A player thus can use Magic Card to increase opponent's Avatar Card size and then defeat it to make bigger damage to the opponent's life points.

On the other hand, Magic Card and Trap Card are used to create helpful situation to support the player by enhancing the player's Avatar Card or disturbing opponent's Avatar Card. The attributes of Magic Card and Trap Card are almost the same, but the timing of using the two card types are different. Magic Card can be used by the player directly at his/her main phase whereas Trap Card can only react according to the opponent's actions. This research doesn't design Power Card but use "Action Point (AP)" to limit how many atom actions a player can do in a turn to simplify the game rules. Players need to pay specific APs for each atom action.

Table 7. The computerized TCG's card types and its attributes

Card Categories	Card Type	Definition	Related Attributes
Avatar Card	**Avatar Card**	Fight with other Avatar Card.	Attacking Power, Hit Point, Size, Race, Rank etc.
Tool Card	**Magic Card**	Active: players can use it actively. Magic Card can alter other cards' attribute values.	Description/Effect, Duration, Rank, Scope etc.
	Trap Card	Passive: players can't use it directly; it will be triggered by opponent's actions.	
Power Card		**N/A**	

Game Field

Figure 2 shows the game field, which has two sides that this research designed for two players. Each side has four areas based on the analysis in Table 5. The four areas are Hand (H), Deck (D), Graveyard (G), and Field where two kinds of cards, Avatar Card (A) and Tool Card (T), can be placed. Table 8 lists each area's notation, the description, and the card type restriction. For example, A^p_i means the area where player p can place only one of his/her Avatar Cards in his/her hands, H^p_k.

As Figure 2 shows, each player can place his/her Avatar Card into one of six places which are presented in three rows; the first row contains A^p_1; the second row contains A^p_2 and A^p_3: and the third row contains A^p_4, A^p_5 and A^p_6. Each row makes a sense of "distance" to the others. Therefore, if an Avatar Card's "attack range" (the Avatar Card's attribute represents how far the Avatar Card can attack) is shorter than the distance between it and its target, the player must do "move" atom action to make it closer to its target (but, the player can never move or put his/her Avatar Card into the opponent's game field).
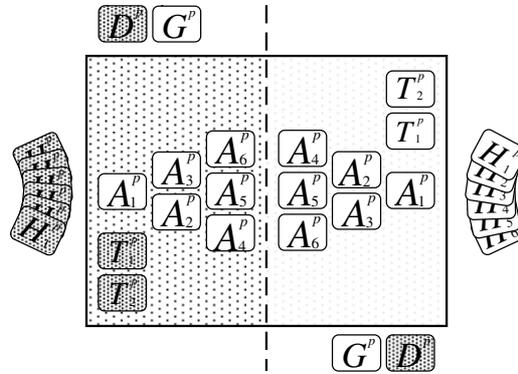
Fig. 2. The Game Field of the two players computerized TCG

Table 8. Four major areas in the Game Field and its notations and descriptions

	Area	Notation	Description
Cards in player's hand	Hand	H^p_k	Cards have been drawn but not used yet. These cards are hold in player's hand.
Card set for player drawing	Deck	D^p	Face-down cards and no one can take a peek to them. Player must draws from the top.
Used or destroyed cards	Graveyard	G^p	Face-up cards and can be checked at anytime.
Cards in using	Field	A^p_i	Places for Avatar Card.
		T^p_j	Places for Tool Card.

Player Schema

As the player analysis mentioned in Section 3, two attributes are designed for the player schema in the computerized TCG:

- Life points: When a player loses his/her Avatar Card, his/her life points would drop down according to the rule and will loses the game if life points $\leqq 0$.
- Remaining Cards: If a player needs to draw a card but cannot accomplish due to he/she has no more cards in the Deck area, then the player loses the game.

Table 9. Phases in one turn and actions in each phase

	Phases in this research	Actions in each phase
Initial Phase	Draw Phase	Draw a card from deck.
Main Phase	Combat Phase	Player can do the following atom actions if still have APs: • Play • Defend • Attack • Move • Magic Table 10 lists detailed descriptions and AP costs.
Final Phase	Discard Phase	Discard cards if needed.

4.2 Rule Design

At the beginning of the game, each player has 20 life points, 40 cards in the Deck and can draw 6 cards from the Deck as the preparation. The goal of the computerized TCG is to reduce opponent's life points and try to make it be zero. If the opponent runs out of his/her cards in the Deck area, the player will also win the game. After both players get ready to start, one of the two players begins his/her first turn. Each player has 3 APs to spend for doing atom actions. One turn in the computerized TCG has three phases as Table 9 lists and several available atom actions as Table 10 lists. When a player completed his/her turn, the next player starts his/her turn. The game will be end until one of the two players reaches the game goal.

Table 10. Atom actions at the combat phase and its AP costs

Atom Action	AP costs	Action description
Play	1	Put a card on the correct place in game field. Avatar Card must be face-up but effect cards must be face-down.
Defend	1	Take defensive pose for the possible incoming attacks.
Attack	1	Attack an opponent's Avatar Card.
Move	1	Move an Avatar Card to another place.
Magic	1	Use a Magic Card in hands.
	0	Use a Magic Card in the game field.

Table 11. Game rules and some examples

Rule Type	Examples
Card↔Card	• Avatar Card can attack opponent's Avatar Card and cause damage based on the following formula: If the opponent's Avatar Card is defending, then: *Damage = Attacker's attacking power – defender's defensive power* Else: *Damage = Attacker's attacking power* • Magic Card can increase or decrease Avatar Card's attribute values; or can destroy opponent's Tool Card. • Trap Card will be triggered and reacted by opponent's attack action or magic action automatically.
Card↔Game Field	• If a card is discarded, defeated, expired or destroyed, then the player needs to remove them into the graveyard.
Card↔Player	• If an Avatar Card is defeated, the player's life points will be taken based on his/her Avatar Card's "size" attribute. For instance, *size* is defined as an integer and its value is from 0 to 3, the larger number means the avatar is bigger (but doesn't mean the avatar is stronger): *Player's Life Point will be taken* $= 2^{size}$
Game Field↔Player	• If the player runs out his/her cards in the deck, then the player loses. • Player can take play action to put cards in the game field.

Phases are order sensitive. For instance, once a player has announced that he/she completed his/her Combat Phase, then the player will be not allowed to go back to either Draw Phase or Combat Phase again. However, the atom actions are order insensitive. Means player can do any atom actions as long as he/she still has APs to spend. Table 11 lists the rules of the computerized TCG developed by this research.

4.3 Cards as Reward

To keep students' motivation of learning, this research provides an environment in which students can use the cards they've got from learning. For instances, the teacher can give the student cards if the student did well in either his/her homework, quiz, or exam; or the teacher can give the student different level cards according to his/her answers to the question the teacher asked; or the learning management system can give the student cards according to his/her learning attitudes and performance. The computerized TCG can increase the rewards (cards) usability and stimulate students' learning motivations because of more they've learned or better they've performed, more and better cards they can get and use to play the game and defeat their fellows.

As Figure 3 shows, teachers can pre-define the relations between the learning and the reward, the system then can give appropriate cards to students automatically.
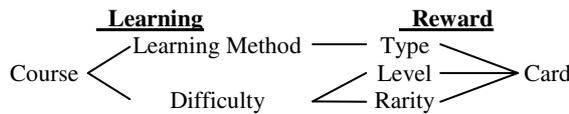

Fig. 3. The relations between the learning and the educational reward

According to Figure 3, different cards may be delivered to the student due to the course difficulty. For example, students could get Tool Card after got good marks for their paper-pencil exam and get Avatar Card after got good marks for their online exam. Also, the card's level or rarity may correlate with the difficulty of the exam. The relations between the learning and the reward make students want to learn and challenge in order to get more valuable cards. Furthermore, because of the cards and the computerized TCG is independent from the courses, teachers can use the same cards as rewards of different courses to let students get cards from all courses.

5 Prototype System

The prototype system of the computerized TCG can be used as educational reward system. Figure 4 illustrates the educational reward system flow. First of all, the teacher created questions and built the relations between cards and the questions (step 1 in Figure 4). Second, the students can start their learning by using either traditional classroom learning or e-learning (includes mobile learning) (step 2). Third, the server then calculates the students' learning performances and delivers cards to the students automatically (step 3). Fourth, the students can use the cards they've collected to play TCG with others just for fun (step 4). Fifth, the game play process could be recorded
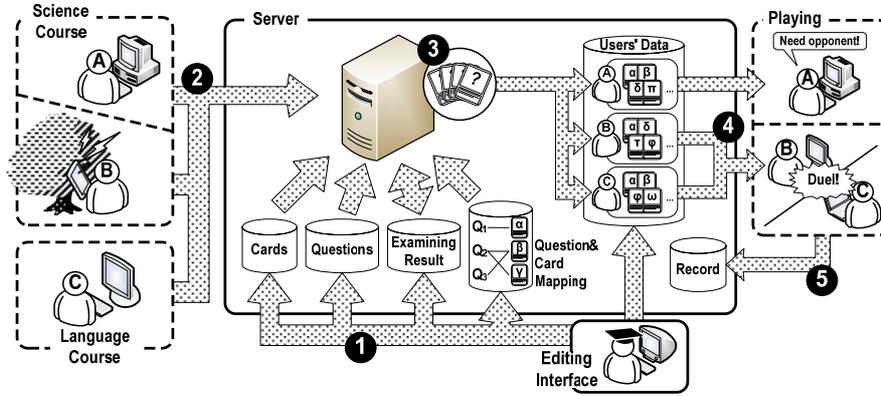
Fig. 4. Computerized TCG System Flow

for future study (step 5). Because of the computerized TCG is a real game, so the students can have fun from it without pressure. Also, the cards are educational rewards, so the students would want to collect the rare and powerful cards via learning and/or practices in order to defeat others.
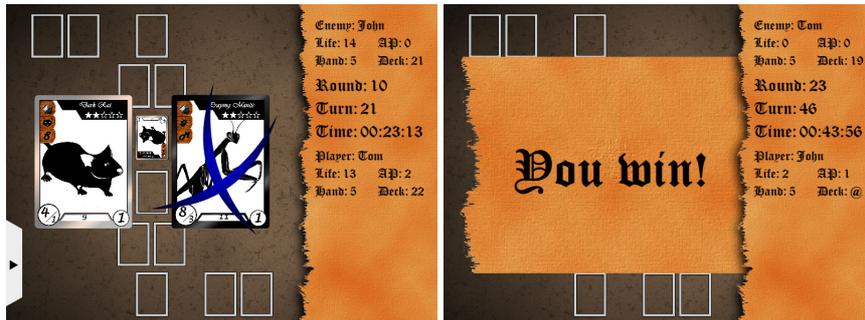

Fig. 5. System snapshot: (left) Tom uses Avatar Card, "Dark Rat", to attack John's Avatar Card, "Praying Mantis"; (right) John wins the game

Figure 5 shows two snapshots of the computerized TCG. Figure 5(left) is Tom's screen shot which shows Tom using his Avatar Card to attack John's. The left part of the screen is the game field and the right part is players' status. The player's status is at the bottom side and the opponent's status is at the upper side. Figure 5(right) is John's screen shot and shows the game result, John wins the game.

6   Conclusion

This research analyzed three famous TCGs and implemented a prototype computerized TCG and educational reward system to increase student's learning motivation.

Students can collect and use cards to play or even show-off, which can really encourage students to learn in order to get new cards. Moreover, because the computerized TCG is real game, it is fun and will not make students feel they are still "learning". The cards and the pre-defined relations between the courses and rewards make the educational reward system can be used in variety disciplines and courses.

There are still several issues needed to discuss to improve this research. The efficiency of using cards in TCG as educational reward should be evaluated via quantitative and qualitative experiment results. How to help teachers dispatching different cards as different educational reward in the traditional classroom settings could be an important issue in practice.

Acknowledgments

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