

Playfulness-based Design in Educational Games: A perspective on an Evolutionary Contest Game

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ABSTRACT

Playfulness steering is an emerging approach in educational game design and play. The integration of arithmetic computation, game strategy, and teamwork into one game allows players to interactively “steer” the playfulness and enhance learning. In this paper, an evolutionary contest game was designed and implemented to examine the influencing factors. Through action research, focus groups and hermeneutic methods, the results of this study suggest that the playfulness design of an evolutionary game is influenced by the degree of uncertainty, flexibility in decision making, the level of challenge, equal conditions for fair play, opportunities to compete/cooperate, and the level of interactivity.

Keywords: educational games, playfulness, evolutionary game, game design, types of game.

INTRODUCTION

The trend towards increasing use of games for learning has become an important tool for “net generation” learning. When players are interested in something, it keeps them engaged, and when their attention is on one thing, they are described as playful (Eysenck & Keane, 2000). Webster and Martocchio (1992) define playfulness as the device that attracts players’ attention and involves them during their play. Nevertheless, there has been worry that educational games lack playfulness, which will not arouse students’ interest in playing to

learn (de Freitas and Oliver, 2006). Brown and Boltz (2002) agree that attention is one of the most important psychological processes that regulate the experience of flow (Woszczyński, Roth & Segars, 2002). In other words, the duration of the flow experience has a large effect on whether a player describes their interactions as playful or not (Woszczyński, Roth & Segars, 2002).

Playful devices include online and offline games. The viewer's use of offline playful games can extend the impact of learning positively (Woszczyński, Roth & Segars, 2002; Csikszentmihalyi, 1990; Hoffman & Novaka, 1996), promote more exploratory behaviors (Ghani, 1991; Hoffman & Novaka, 1996), increase curiosity and intrinsic interest (Webster et al., 1993), heighten openness (Woszczyński, Roth & Segars, 2002; Martocchio & Webster, 1992), and encourage self-efficacy (Potosky, 2002). In addition, Martocchio and Webster (1992) reported that computer playfulness is not only correlated with positive computer attitudes, less computer anxiety, and positive mood when using computers, but also more strongly related to such outcomes as learning, mood, and satisfaction than computer anxiety or computer attitudes.

In the sense of playing, if students cannot get involved, make mistakes, self-challenge, and learn, then they will not find interest (Schank, 1997). Nevertheless, playfulness is characterized as flow experience by some common elements (Pace, 2004): a balance between the challenges of an activity and the skills required to meet those challenges; clear goals and feedback; concentration on the task at hand; a sense of control; a merging of action and awareness; a loss of self-consciousness; a distorted sense of time; and an autotelic experience (Csikszentmihalyi, 1975). If a player fully loses self-consciousness, then learning effectiveness decreases, especially in those games with educational purposes. In other words, when the game becomes too playful for the player, then he or she may not be able to reflect and learn (Bork, 1992; Prensky, 2001). Playfulness and learning can be viewed as two ends of a continuum. To the extreme of playfulness, players will not learn; on the other hand, to the extreme of learning, there is no fun created by the game design and the players' interaction with the game and its design. Therefore, an essential issue for educational game designers is how to design a computer game that both attracts players' attention and enhances learning. Lin, Wu and Tsai (2005) suggest that the playfulness of on- or off-line games will be most influenced by game content design. Therefore, this study focuses on the game content design including the playing rules and structure, and how these design elements influence playfulness.

GAME DESIGN FOR PLAYFULNESS

Play is at the center of all game experiences. But what exactly is play? The idea of a game is that people are engaged in some activities in which they make a palpable and discernable contribution to the outcome. This is done through a process of spontaneous improvisation, exploration, discovery, deduction, and intuition. A game can generally be described as a goal-oriented experience (which may include sub-goals), with a certain configuration of obstacles, resources, rewards and penalties, and various types of information that the players can use in forwarding their objectives (Pearce, 2002). Because game players tend to seek gratification in escape, entertainment, interaction, and surveillance, playful features are a strong factor in influence and engagement (Klein, 2000).

As noted earlier, computer playfulness has been defined by these researchers as a motivation-related, but relatively stable individual attribute that represents an individual's experience of cognitive spontaneity when interacting with computer games. Therefore, computer game design has to involve the learners with positive engagement (Kiili, 2005). As Dietrich (2004) notes, flow or playfulness allows someone to be fully engaged in the task at hand while experiencing a decrease in self-consciousness, attention to the passage of time and a sense of failure. Csikszentmihalyi (1996) suggests that participants experience flow as long as the activity is challenging, absorbing, matched to a player's skill level, and provides clear goals and unambiguous feedback. Flow experience is subject mainly to two factors: personal skill levels and the challenges of the activity. Influenced mostly by individual working memory (Kiili, 2004; Miller, 1956), personal skill levels in turn have effect on the level of playfulness experience. As for the challenge level, if the task at hand proves too challenging to the player, he may experience too much anxiety while playing; on the contrary, limited challenges would probably leave the player bored (Kiili, 2005).

Kiili (2005) suggests a model that can be used when designing playfulness in educational games. His model describes learning as a cyclic process through direct experience in the game world. The experiential gaming model consists of an ideation loop, an experience loop and a challenge bank. The operational principle of the model can be derived from the human blood-vascular system. The challenges based on educational objectives form the heart of the model. The task of the heart is to sustain the motivation and engagement of the player by pumping appropriate challenges to him or her. To overcome the challenges, a player generates solutions in the ideation loop reflecting lesser circulation.

Playfulness is generated through design. Playfulness-based game design focuses on repetition, variation and rules (Coyne, 2003). The designer can incorporate repetition in a

game by including repetitive drills, while involving variation by varying goals and gaming approaches. On the other hand, the rules of a game can keep players from varying game rules at will and ensure fairness between players.

Keller (1983) suggests that in the content design of games, four essential elements are considered to motivate learners: arousing interest, creating relevance, developing an expectancy of success, and producing satisfaction for players. Northrup (2001) divides game-based interaction into five categories: interaction with content, interaction or collaboration with people, trade-off selections limited on players, challenge and support for players, and player transformation. Andresen and Ahdell (2002) add that effective game-based learning provides fun and engagement with crucial elements such as interactivity, flexibility, dramatic effects, ease of device use, competition and realism. Price, Rogers, Scaife, Stanton, & Neale (2003), on the other hand, suggest that the playfulness of games is modified by the level of user engagement, reflection, imagination, collaboration and exploration through interaction. As Tapscott (1998) believes, good games that inspire user engagement or playfulness enable them to explore and think and thereby encourage participation of non-users.

The six design elements that Andresen and Ahdell (2002) suggest above mainly apply to designing on-line games. Dramatic effects and realism in particular are key factors in games that keep users motivated. This study, on the other hand, focuses on developing a game-based learning platform that decreases the use of such elements; instead, players enjoy the game through user interaction and collaboration, as suggested by Price, et al (2003). With a theoretical framework based on the six-element theory by Andresen & Ahdell (2002) and five-condition theory by Price, et al (2003)., this study organized characteristics of game-based learning into six key categories: degree of uncertainty, equal conditions for fair play, opportunities for competition and cooperation, level of challenge, flexibility in decision making, and level of interactivity, as described below:

1. Degree of uncertainty

Classical game theory predicts that a group of self-interested players will reach a set of strategies, known as Nash Equilibrium (Nash, 1950), from which no players can increase their payoffs individually. Similar to the experimental studies on expected utility theory, however, empirical studies have frequently demonstrated that people seldom play without prediction (Camerer, 2003).

Moreover, Kahneman and Tversky (1982) distinguish two types of uncertainty as external uncertainty and internal uncertainty. External uncertainty occurs whenever we think that our uncertainty is due to coincidental chance events in a world which we cannot control.

Differing from those related to external uncertainty, internal uncertainty is induced by varying the degrees of instructed knowledge about the winning rules (Teigen, 1994). Games require a balance between external and internal uncertainty. For example, people commonly express disappointment even when the outcomes of their decisions are determined entirely by chance, and animals react negatively even when they are merely exposed to the possibility of receiving a better outcome (Brosnan & de Waal, 2003). Then, the game of Strike Up will encompass and examine the factor of uncertainty effecting to playfulness.

2. Equal conditions for fair play

John Nash proposed the Nash Equilibrium in the 1950s. He argued that if there is a set of strategies with the property that no player can benefit by changing his strategy while the other players keep their strategies unchanged, then that set of strategies and the corresponding payoffs constitute the Nash Equilibrium. This indicates that no player will obtain a higher expected utility by making a different decision, if each other player's decision is viewed as fixed (Vlaev & Chater, 2006). From the extensions of this game theory, the equilibrium notion has been redefined in a number of ways (Fudenberg & Tirole, 1991; Vlaev & Chater, 2006).

Colman (2004) proposes yet another game structure. When two (or more) decision makers in a game both have equal knowledge of game-specific strategies, then both or more players believe they have opportunities to win the game. As a result they will continue to engage in playing that game. In addition, the interactivity will be affected by the incentive scheme and the fairness of rules (Baldwin & Bengtsson, 2004). This theoretical hypothesis will be tested in the multi-team cooperative game *Strike Up*.

3. Opportunities for Competition and Cooperation

Based on the motives for interaction and the intensity of the relationships concerned, five types of interaction are distinguished: conflict, competition, co-existence, cooperation, and collusion (Easton & Araujo, 1992). Conflict and competition are described as active vis-à-vis competitors, although they differ in terms of the motives for specific interaction. Conflict represents object-oriented competition, geared to destroying the opposing counterpart. Competition is goal-oriented, directed towards achieving one's own goals even though this may have a negative effect on other competitors. Co-existent competition occurs when actors do not see one another as competitors, and therefore act independently of each other. Finally, in cooperation, the companies involved strive towards the same goals, for example by

working together in strategic alliances or projects. Easton and Araujo (1992) argue that interaction between competitors is variable and can involve both cooperative and competitive interaction.

Deutsch (1962) argues that collaboration takes place *when individuals form a team in which they strive for a shared goal*. Tauer and Harackiewicz (2004) propose that *competition* is characterized by four features. First, the winner is not explicitly identified. Second, opponents are similar, if not equally matched so every player stands a chance of winning. Third, the rules are well-defined to ensure fairness. Finally, competitors are able to estimate their own progress against opponents. *Competition* is complete with these four elements, and can be as effective in motivating students as *cooperation*. Studies exist to show that individual performance benefits from competition among teams (Erev, Bornstein, & Galili, 1993; Reeve & Deci, 1996). *Competition* is one key feature to all kinds of *playing* because it increases *playfulness* (Lieberman, 1977) or *fun engagement* of the game (Natriello, 1984). In addition, Haynes, Smith and Turk (2003) point out that a shift from individual performance to competition and collaboration increases game-supported experience sharing in which slow learners progress by observing strategies used by fast learners. Thus, the impact of competition-cooperation on the game playfulness will be viewed in the Strike Up game.

4. Level of Challenge

The game offers challenges arising from activities without known outcomes, most likely due to the hidden, random, and multi-layered information in the game (Malone, 1981). Hidden or random information will create a challenge for students, and multi-layered information will result in the complexity for students to manage. The word *complex* can be defined as *consisting of interconnected or interwoven parts* (Batra & Wishart, 2004). Sorrentino, Simithson, Hodson, Roney, and Walker (2003) suggest that game complexity is proportional to the level of uncertainty in it. To be more specific, the more uncertain the surrounding situations are in a game, the more complex the tasks become. Besides uncertainties, they add, individual motivation also influences game complexity. Mosleh and Chang (2004) emphasize that one's knowledge base influences one's working memory. In other words, people with different knowledge bases perceive task complexity differently. Game difficulty taxes one's working memory, and in turn increases cognitive strain (Evans, 1983). Daily, Lovett, and Reder (2001) also point out that given difference in individual working memory, people perceive complexity of a task differently.

On the other hands, Brodeur and Boden (2001) state that children do not perform well when they have no control over allocate their attention. Brodeur (2004), in addition, points out that the children benefit from the ability to assess task difficulty, which prevents them from making habitual responses to that task. Students make progress in games that require them to constantly reflect and perceive the difficulty of the rules. Rule difficulty plays a key role in how much rule switching should be made. Tasks with little rule difficulty tend to prevent children from thinking flexibly. Overly difficult or abstract rules, nevertheless, deprive them of fun and game engagement (Deak, Ray, & Pick, 2004).

In considering the complexity and difficulty of a game will effect the playfulness, this study set up some flexible and some fixed rules to give challenges to the players.

5. Flexibility in making decisions

In the context of a game, players determine their strategy choice by gauging opponents' thinking and observing their behavior (Hedden & Zhang, 2002). Rules of a game give players a set of options that allow them to proceed within the designated framework. In the process of playing, the probabilistic thinking and furcating-based decision-making factors may influence players' predictions and decisions (Harris, 2003).

In neither of the above games can players predict the outcome of their opponents' next move (invisible opponents). In addition to those factors influencing players to make decisions, trade-off mechanism embedded in games will allow player to take risks by which the engagement of game will promoted. Then, the numbers for calculation, function cards to be applied and trade-off schemes to be choiced in the game will be designed to promote the game playfulness.

6. Level of Interactivity

Game theory characterizes the problem of social interaction with a payoff matrix for multiple decision makers (players) and a set of alternative actions available to each player. Generally, games can be divided by their structure into two types: one with the players making concurrent moves, and the other with them acting in turn (Abele, Bless, & Ehrhart, 2004). The two are labeled as simultaneous and sequential games, respectively. Downes and McMillan (2000) used a qualitative approach to identify six interactivity dimensions: direction of communication; time flexibility; sense of place; level of control; responsiveness and perceived purpose of communication. The choice dimension does not refer simply to informational and navigational alternatives for human users. But, such user- and system-

friendly choices reduce user confusion and frustration (Chen & Yen, 2004) and will increase the engagement of game. The game used in this study, however, will involve visible opponents as players are allowed to make their own decisions while taking turns playing.

Drawing on the points above, this research takes as a model the content design of *Strike Up* to explore optimal designs for integrating the six elements into a game that provides a ‘playful’ experience for adolescent calculus students.

GAME CONTENT DEVELOPMENT

1. *Strike Up*: Background

Bonnie Anderson from University of Illinois developed WEST, the first computerized game-based learning platform in 1976 (Sleeman & Brown, 1982). WEST helped enhance students’ learning motivation by encouraging them to compete against the computer in various game contexts. The player’s goal was to beat the computer by using four arithmetic skills (Dugdale & Kibbey, 1997). Given the growth in popularity of computer game-based learning in Taiwan in the 90s, Professor T.W. Chen and his research team from Taiwan’s National Central University launched a series of *Internet-supported peer-to-peer learning systems* by augmenting WEST into a decentralized learning system called *Distributed WEST* (Chan & Baskin, 1990).

To be used as a research tool for the study, the game *Strike Up* was revised from WEST based on the above theoretical statements. In terms of the game’s *drill & practice* function, researchers changed the learning theme to *four arithmetic operations* which subjects are more familiar with to K4 and above students. On the game’s *competition* mode, players of *Strike Up* have two choices, 2 vs. 2 mode or 3 vs. 3 mode (see appendix 1).

Moreover, dice are substituted with playing cards to increase game complexity. Each card dictates different game conditions, *Number Cards* are used to indicate numbers used in arithmetic operations, while certain cards are designated as special *Function Cards*. Some cards limit or increase players’ use of four mathematical symbols ($+$; $-$; \times ; \div). For example, mathematical parenthesis “()” may be added to adjust game complexity for different players. In terms of game difficulty, the original *bumping range* was enlarged to increase game difficulty.

2. Types of games

Squire (2003) categorizes digital games into drill & practice games and simulation games. Some games are regularly used for education purpose due to their easier integration into conventional teaching, such as *enrichment exercises* during users' independent research periods. Another example is *simulation games*, such as war games that involve role-playing for users to perceive issues from different perspectives that come with a new identity. Prensky (2001), on the other hand, proposes an eight-category classification of digital games, including action, adventure, fighting, puzzle, role-playing, simulation, sports, and strategy games. In contrast to Prensky (2001), Squire (2003) divides games into *exercise type* and *simulation type*.

Leslie, Friedman and German (2004) classifies types of learning into domain-specific and domain-general according to the educational implications embedded therein. Domain-specific learning focuses on acquisition of subject-specific knowledge, whereas domain-general learning emphasizes user's analysis and reasoning abilities. Moreover, games can be divided into drill & practice type, single combat type, stable contest type, evolutionary contest type and contextual type according to the inherent limitations on game goals and strategy choices. Those types are illustrated as follows:

1. ***Drill & practice game***: Domain-specific games that encourage players to solve problems by correctly applying knowledge, but give players less chance to exercise game strategies.
2. ***Single combat game***: The games require players to use domain-general knowledge under time constraint; players may combat alone or team up with partners against virtual player in computer or related devices.
3. ***Stable contest game***: The games require players to apply domain-specific and domain-general knowledge interchangeably; players use one or two simple sets of strategies in combats.
4. ***Evolutionary contest game***: The games are played between two teams or many teams as game context and strategies continue to change in every turn. Some of them emphasize players' use of domain-specific knowledge, while others focus on domain-general knowledge.
5. ***Contextual game***: The problem-solving games are played between two teams or among many teams. Players have to go through analysis, hypothesis, and verification stages to win the game. Success relies heavily on player's domain-specific knowledge supplemented by domain-general knowledge e.g. role play.

An Evolutionary game is essentially an agent-oriented game. The game design is based on four factors: 1). *Interactivity*: Learners are required to solve problems; 2). *Reflection*. Learners give reasons for choosing the problem-solving method; 3). *Feedback*: Learners' mistakes are identified; and 4). *Guidance*: Game software provides an explanation of answers and opportunities to explore game context, test hypotheses, and construct concepts (Kiili, 2005). In a dynamic game scenario, players must constantly evaluate and adjust the competition/collaboration strategies (Menasche, Figueiredo, & Silva, 2005; Sigmund and Nowak, 1999), thereby engaging themselves in logical thinking (Menasche et al., 2005). *Evolutionary contest games* encourage players to adapt decision-making to complex information input. Several design principles are crucial to *Evolutionary contest games*: 1). Games are played among teams composed of several team members. 2). Player interaction continues as time elapses. 3). Players choose from different game modes; 4). Player decisions are associated with valuable vectors 5). Players adjust game strategies according to game dynamics (Menasche, et al., 2005).

The research tool *Strike Up* enables players to interact with content, collaborate with peers, and benefit from player support (Northrup, 2001). It also allows players to decide on game rules and boundaries (Turkle, 1984). It is both a strategy game according to Peabody (1997), and a contest and constructive learning (Prensky, 2001). Thus, *Strike Up* game can be considered as an Evolutionary game.

RESEARCH DESIGN AND RESULT

Three phases took place during this study: design rules and features of *Strike Up*; factors influencing playfulness; and identifying key factors influencing playfulness. The individual research method and results will be discussed according to the developmental phases. The teachers were invited as experts to participate in the planning and completion of each phase. At each phase, eight teachers presented the *Strike Up* game to his or her k-5 or k-6 students to play at least 3 times. The teachers were invited as experts to participate in action research, focus group panel discussions and hermeneutic coding.

Identifying the key factors influencing playfulness

Martocchio & Webster (1992) argue that players who are higher in cognitive playfulness would be more spontaneous, inventive, and imaginative when interacting with computers. Their research has also suggested that an individual's tendency to interact playfully with

computers is positively related to game content design (Martocchio & Webster, 1992). Computer playfulness may also explain why some individuals will show greater increases in self-efficacy (Potosky, 2002). Phase III examines the relationship between playfulness and game content design by using a hermeneutic research approach.

Research method: Hermeneutic approach

Practitioners 'know' playing will be influenced by many things; practice context, team structures, level of education and experiential development. This raises the issue of relativity of knowledge. Can we accept that some dimensions of playing knowledge are transitory and open to development and refinement? Indeed plurality fits well with a practice which 'values the role of perception, uniqueness and individuality in game playing'. The issue is also raised by Pearson (1992) who stresses the need to move from an individual perspective on knowledge to a more collectivist approach where individual knowledge is articulated, shared and made available to others. This would allow a critical review of knowledge to be made visible.

Until recently there has been limited encouragement to articulate this dimension of knowledge. Indeed, there has been a tendency to focus on more technical rationality or codified knowledge. By discussing with learners, mentors or experts are inclined to draw on the theory that informs player's perceptions and emotions, rather than the particular knowledge developed as a consequence of being exposed to a game situation. One reason for using this may be that practitioners lack the means to express this type of knowledge. At the same time some players may easily identify their intention in game playing but they know they would experience difficulty in describing what they have been doing (Fish, Twinn, & Purr, 1991).

The hermeneutic strand of phenomenology specifically engages with the problem of making the implicit more explicit. The purpose of hermeneutics is to bring 'into nearness that which tends to be obscure' (van Manen, 1990). Therefore, the hermeneutic approach can examine the awareness of game mentors without them thinking about it. The hermeneutic approach asked game mentors to remember and interpret their pre-reflexive consciousness of observing students' game playing and then construct the dimensions and articulate the sense of discovery in students' playing (Schwandt, 1994).

The hermeneutic method proceeds as follows: 1) Develop a checklist by categorizing the results obtained from focus group panel discussion. 2) Let the experts understand what the

categories are and what they are all about, and have discussions about the checklist. 3) Let the experts revise the checklist using the similarities or differences between ideas. 4) Repeat steps 2) and 3) until the experts agree upon all the categories and how they work. 5) Separate the eight experts into two groups of four. 6) The experts code or weight each category in the checklist. 7) Categorize what the experts have coded respectively. 8) Have the codes of the two groups go through Kappa coefficient of agreement. 9) Analyze their consistency before determining their correlation.

The Findings: Explanatory power of playfulness

Based on the former two phases, a checklist was developed during the third part of this study. This checklist includes **six** major categories, namely “degree of uncertainty”, “flexibility in decision-making”, “equal opportunities for fair play”, “opportunities for competition and cooperation”, “level of challenge”, and “degree of interactivity”, under which lie 30 items altogether. Following the research procedure of the hermeneutic approach, the teachers who conducted *Strike Up* at least three times categorized the 30 items on the checklist and made corresponding revisions to this checklist. Finally, the eight teachers were divided into two groups of four to code or weigh the explanatory power of playfulness as follows:

Correlation evaluated by group A	Correlation evaluated by group B	Features influencing “playfulness” of the game
		1. Degree of uncertainty
High	High	(1) Players being unable to predict whether or when they will be “bumped back” by other players
Low	Low	(2) Players being unable to predict what Number Cards they will get
High	High	(3) Players being unable to predict what Function Cards they will get by which they will be punished or awarded.
Medium	Medium	(4) Head starts in the game not guaranteeing victory.
Medium	Medium	(5) Players being “bumped back” more frequently when most players crowd near the end and are clump together.
Medium	Medium	(6) Players having to move backwards if the calculated number exceeds the exact number it takes to stop right at the finish.
High	High	(7) Players who are good at arithmetic operations not necessarily winning the game
		2. Flexibility in Decision-making:

High	High	(1) Players diversifying game strategies based on permutations of the Number Cards
High	High	(2) Players using the Function Cards to help or sabotage other players.
Low	Low	(3) Players having to choose between maximal or optimal moves.
Low	Low	(4) Players having to decide whether or not to enter the “Safety Area”
3. Equal condition for play fairly		
Medium	Medium	(1) Involving players with similar math ability
Medium	Medium	(2) Function Cards being adjusted to favor players with lower math abilities
Medium	Low	(3) Players with lower math proficiency being allowed to draw less Number Cards
High	High	(4) The game rules applying to all players without discrimination.
High	High	(5) Each team consisting of players who are both good and poor at math.
Medium	Medium	(6) Players having to constantly consider the “trade-off” of subsequent success.
4. Opportunities for Competition and Cooperation:		
Medium	High	(1) Team players collaborating so less capable players feel comfortable throughout the contest.
Medium	Medium	(2) The collaborative nature of the game engaging strong internal and external motivation to win.
High	Medium	(3) Speed of arithmetic operation being incorporated in the game as an extrinsic motivation to enhance the engagement of players.
5. Challenges:		
Medium	Medium	(1) Difficulty for players to come up with the exact number to reach the finish.
High	High	(2) Difficulty for players to calculate with so many Number Cards.
High	High	(3) Complexity of game rules.
Medium	Medium	(4) The combination of Number Cards and Function Cards creating challenges for moving backward or forward.
High	High	(5) The “bump-back range” creating challenges.

Medium	Medium	(6) The time limitation of playing creating pressure.
Medium	Medium	(7) The appropriate cognitive load for arithmetic operation to meet challenges.
6. Interactivity:		
Low	Low	(1) Players not having to wait too long for their turn.
Medium	Medium	(2) Players having opportunities to discuss with and help teammates in calculating
Low	High	(3) The game providing opportunities for mutual assistance.

According to the above hermeneutic analysis of the attributes of playfulness in *Strike Up*, this study has developed the general checklist for items of playfulness. After reviewing the checklist, the two groups of teachers coded the level of correlation for each item as High, Medium, and Low. The final results were then analyzed using Kappa analysis, shown as follows:

B \ A	High	Medium	Low	Total
High	10	1	1	12
Medium	1	12	0	13
Low	0	1	4	5
Total	11	14	5	30

The proportion corresponding (PC) is $\frac{26}{30} = 0.867$

Code	Marginal frequencies	EPC
High	$\frac{12}{30} \times \frac{11}{30}$	0.147
Medium	$\frac{13}{30} \times \frac{14}{30}$	0.202
Low	$\frac{5}{30} \times \frac{5}{30}$	0.028
Total		0.377

The expected proportion corresponding (EPC) is 0.377

$$\text{Kappa} = \frac{PC - EPC}{1 - EPC} = \frac{0.867 - 0.377}{1 - 0.377} = 0.787$$

With the Kappa analysis, if the Kappa value goes beyond 0.70, it then denotes an obvious quality.

It was found that the two groups of teachers show much similarity in their respective evaluation results. From both groups, 10 items received High correlation, 12 received Medium, and four received Low. Altogether, 26 items out of 30 shared the same rating from both groups. Therefore,

The proportion corresponding (PC) is $\frac{26}{30} = 0.867$

The expected proportion corresponding (EPC) of the items is 0.377

$$\text{Kappa} = \frac{PC - EPC}{1 - EPC} = \frac{0.867 - 0.377}{1 - 0.377} = 0.787$$

. Since $0.787 > 0.70$, the Kappa value then indicates an obvious quality.

From the above information, several conclusions can thus be drawn:

1. Degree of Uncertainty

Both groups of teachers give “High” correlation to the following three items under degree of uncertainty: “Players being unable to predict whether or when they will be ‘bumped back’ by other players”; “Players being unable to predict what Function Cards their team or opponent will get”, and “Players who are good at arithmetic operations not necessarily winning the game.”

Similarly, both groups gave “Medium” correlation to another three items: “A head start in the game not always guaranteeing victory.” “Players getting “bumped back” more frequently when most players crowd near the end”, “Players having to move backwards if the calculated number exceeds the exact number it takes to stop right at the finish.”

As for the remaining item, “Players being unable to predict what Number Cards they will get,” both groups coded it as “Low”. The above results indicate that under the category “Degree of uncertainty”, the three items coded as “High” in the evaluation play a major role in promoting playfulness in *Strike Up*.

2. Flexibility in Decision-making

Under this category, both groups coded the following two items as “High”: “Players being able to diversify game strategies based on permutations of the Number Cards” and “Players being able to use the Function Cards to help or sabotage other players.”

“Players having to choose between maximal or optimal moves” and “Players having to decide whether or not to enter the Safety Area”, were observed as having “Low” correlation with playfulness.

The two items “Players being able to diversify game strategies based on permutations of the Number Cards” and “Players being able to use the Function Cards to help or sabotage other players” both played a major role in increasing playfulness in *Strike Up*.

3. Equal Conditions for Fair Play

Three items under this category were coded as “Medium” for their correlation by both groups. They are “The game involves players with similar math ability”, “Function Cards” are adjusted to favor players with lower math abilities”, and “Players have to constantly consider the trade-offs of each move.”

This time in the evaluation, the game did not offer different versions of playing for students with varying arithmetic skills. Therefore, the two groups gave “Medium” and “Low” correlation respectively to “Players with lower math proficiency being allowed to draw less Number Cards.”

4. Opportunities for Cooperation and Competition

For the item “Team players collaborating so less capable players feel comfortable throughout the contest”, the two groups observed a “Medium” and a “High” correlation. As for “The collaborative nature of the game engaging strong internal and external motivation to win”, both groups coded it as “Medium”, while they observed “High” and “Medium” respectively for the item “Speed being incorporated in the game as an extrinsic motivation to enhance the engagement of players.”

5. Level of Challenge

In *Strike Up*, various rules are set to increase the level of challenge. For example, an optimal value must be found by calculating the figures on the Number Cards, the Function Cards are used to move forward or backward, the Safety Area must be used strategically, the bumping back effect requires a modification in calculations, and the demand to move backward when the player does not stop right at the finish requires more strategic planning and calculating. All these factors mentioned above fill the game with challenges.

Naturally enough, both groups evaluated the three items as highly correlated to the playfulness of the game. These were “**The difficulty for players to calculate with so many**

Number Cards”, **“The complexity of the rules”**, and **“the bumping range”**. To the remaining items under the category “Challenges”, both groups of evaluators observed a “Medium” correlation.

As noted above, the three items coded as “High” bear much relevance to promoting playfulness in *Strike Up*.

6. Interactivity

Under this category, both groups of teachers considered the item “Players having opportunities to discuss with and help teammates in calculating” to be a “Medium” correlation with playfulness in the game, and “Players not having to wait too long for their turn” to be a “Low” correlation. In contrast, they gave both “Low” and “High” correlation to “Opportunities for reciprocal assistance within the team”.

CONCLUSIONS

The researchers subsequently established content design principles on game-based learning according to the six elements (equal conditions for fair play, opportunities for competition and cooperation, level of challenge, degree of uncertainty, flexibility in decision making, and degree of interactivity) previously used to develop *Strike Up*. The design principles to create educational value and promote playfulness are based the diversified contest mode in which makes the game more enjoyable because it leads to increased player interaction, competition, and collaboration and because the more uncertainties there are, the more difficult a task becomes (Sorrentino, Simithson, Hodson, Roney, & Walker, 2003). Besides, this design facilitates learner’s scaffolding among team members and offers strong incentives for students to improve their arithmetic abilities.

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