An Analysis of Creative Process Learning in Computer Game Activities Through Player Experiences

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Abstract

This research investigates the extent to which creative processes can be fostered through computer gaming. It focuses on creative components in games that have been specifically designed for educational purposes: Digital Game Based Learning (DGBL). A behavior analysis for measuring the creative potential of computer game activities and learning outcomes is described. Creative components were measured by examining task motivation and domain-relevant and creativity-relevant skill factors. The research approach applied heuristic checklists in the field of gameplay to analyze the stage of player activities involved in the performance of the task and to examine player experiences with the Player Experience of Need Satisfaction (PENS) survey. Player experiences were influenced by competency, autonomy, intuitive controls, relatedness and presence. This study examines the impact of these activities on the player experience for evaluating learning outcomes through school records. The study is designed to better understand the creative potential of people who are engaged in learning knowledge and skills during the course while playing video games. The findings show the creative potential that occurred to yield levels of creative performance within game play activities to support learning. The anticipated outcome is knowledge on how video games foster creative thinking as an overview of the Creative Potential of Learning Model (CPLN). CPLN clearly describes the interrelationships between principles of learning and creative potential, the interpretation of the results is indispensable.

Keywords: creative potential; learning model; digital game based learning; player experience; game; creative component.

Introduction

A digital game involves role-play characters, complex problems to solve, and compelling music and graphics (Shute, 2011), with knowledge and skills being learned during the course of playing. Games, in general, support the development of critical thinking through visualization, experimentation, and creativity (Amory, 2007). Game elements often provide problem solving experiences as players try to break down the tasks, engage meta-cognitive skills, and think critically (Turcsányi-Szabó, Bedő, & Pluhár, 2006). Games also offer an opportunity to explore new ideas and actions through the diversity of game play opportunities generated by communities of players. While there has been significant growth in game-based learning research in the past two decades (Habgood and Ainsworth, 2011), this research focuses on the games that have been specifically designed for educational purposes and facilitate problem-solving skills. This study investigates how video games foster creative problem solving and learning processes.

Creative Potential

To identify the potential of games to engage the players in creative processes, criteria related to the activities undertaken need to be clearly defined. As mentioned in the works of Paras and Bizzocchi (2005), games have great potential to support creative processes (Paras and Bizzocchi, 2005). Furthermore, creative ideas resulted from the novel combination of ideas (Spearman, 1930). This creativity involves a process of divergent and convergent thinking (Amabile, 1996), in which problem solving plays an important role (Clark, Veldman, & Thorpe, 1965).

Divergent and convergent thinking are the core elements of the creative process. Divergent thinking is important for idea generation (Amabile, 1996) and is necessary to produce many alternative solutions to the problem (Gordon, 1961). Convergent thinking, as a creative process, occurs in the idea validation stage (Amabile, 1996). It allows an individual to select the correct way to approach the task at hand (Sviderskaya, 2011), with the ability to select a single response from a series of alternatives (Clark et al., 1965). To develop interactive experiences that incorporate these valuable and educative learning processes, a clear understanding of how different game elements are combined to produce the creative potential is needed.

Game Activity Components for Creative Gameplay

The creative game potential measures can be identified by analyzing game activities. The game play activities and the creative process components can facilitate creative processes, and the game activities related to the creative potential during game play. Thus, these activities are able to support the learning of individuals (Inchamnan and Wyeth, 2013). Playing games has a significant role in learning to solve problems (Myers, Well, & Lorch, 2010). Game activities have influences on creative potential through creative gameplay. For example, game activity facilitates creative-relevant skills and provides greater opportunities for players to take a wide focus when engaging in gameplay with open-ended goals. The feedback activities provide positive reinforcement, which enhances free-choice and self-awareness (Inchamnan and Wyeth, 2013).

Self-Motivation Reports

The game environment is the medium that allows players to achieve self-motivation. Games significantly extend the range of experiences available to an individual. Enjoyable game

experiences result from players being able to work through the game interface to become immersed in playful activity. Within this study, measurement of player experience is based on self-determination theory (SDT) (Ryan, 2000). SDT has been successfully applied in many study discipline such as sports, education, and leisure domains. Przybylski, Rigby and Ryan (2010) applied SDT to video game player motivation. Based on SDT and other relevant theories (e.g., presence), Przybylski (2010) and his colleagues developed the Player Experience of Need Satisfaction (PENS) measure, which assesses the game play experiences in terms of competence, autonomy, relatedness, intuitive controls, and presence/immersion (Przybylski et al., 2010). The PENS measure the individual player experience by assessing the interface between the player and the action taking place within the game environment and how the action and reaction between player and game satisfies specific psychological needs (Rigby and Ryan, 2011).

In this study, to assess game play experiences, the 21-item PENS survey was adopted. It evaluates game play experience from five dimensions: competency, autonomy, relatedness, presence, and intuitive controls. Each item consists of a statement on a seven-point scale, ranging from 1 to 7. The interactive experience with the game environment allows players to express their creativity and intentions (Sweetser and Johnson, 2004). This learning experience allows players greater freedom in terms of decision-making.

Game Based Learning

There are many new approaches towards education, teaching and learning. Young people are challenged and engaged to identify rewarding learning experiences that will inspire them in the 21st Century (Perrotta, Featherstone, Aston, & Houghton, 2013). The use of video games in education is focused on the emergence of new trends like Game-based learning that support teaching and learning. Game-based learning refers to the use of video games to support teaching and learning (Perrotta et al., 2013). Game environments influence learners to foster their skills, are an essential part of child development today (Prensky, 2005a). and provide fun and engagement (Prensky, 2002).

Games for Learning

Learning experiences allow players greater freedom in terms of decision-making. Games offer an opportunity to explore new creative uses through the diverse ideas generated by communities of players. Learners gain meta-cognitive skills and group identity that could influence experiences for life through motivating game play (Turcsányi-Szabó et al., 2006). Games keep learners motivated (Prensky, 2005b). The main reason that people play games is because the process of game playing is engaging.

Table 1. Principals and Mechanics of Learning (Perrotta et al., 2013)

Principals	Mechanics
– Intrinsic Motivation – Enjoyment and fun – Authenticity – Autonomy – Experiential Learning by doing	– Rules: simple and binary – Clear and challenging goals – Fantasy and difficulty – Self-control and feedback – Social element

Table 1 shows the principals of learning based on game activity. The principles refer to the underlying assumptions and concepts. Mechanics refers to processes and dynamics involved in game-based learning, which are interdependent (Paras and Bizzocchi, 2005). The principals and mechanics involved in game-based learning are studied based on the extent that video games can impact overall academic achievement. The majority of the studies examine the impact of video games on student motivation and their school record: programming, math and art subject areas. Video games allow learners to engage with topics and ideas through interaction and simulation, rather than through the conventional materials and formats of schooling: textbooks, lessons, assignments and so forth (Perrotta et al., 2013). To understand to what extent gaming impacts learning outcomes, this study examined the relationships between participants' self-reports and academic learning outcomes.

Behavior Analysis

Behavior is the activity of living organisms including how they move, what they say, what they think, or how they feel. The experimental analysis of behavior has uncovered a number of basic principles about how behavior works as a function of environmental variables (Cooper et al., 2007). Behavioral assessment involves a variety of methods including direct observations, interviews, checklists, and tests (Cooper et al., 2007). Direct measurement is concerned with measurement of the specific behavior to be taught. For example, direct measurement must provide data on student response to the actual materials used in the instructional setting (Cooper, 1982). Applied behavioral analysis is concerned with the manipulation of environmental stimuli (Cooper, 1982). Games create environments where each challenge stands alone and is addressed that way by a player. This study focuses on the game environments that foster creative processes by using behavior analysis. Behavioral assessment allows analysis of creativity from a divergent thinking and convergent thinking perspective. Measurement of divergent and convergent thinking can be used in the identification and development of creative potential (Schaefer, 1969).

Factor Analysis

Factor analysis is one of the most commonly used procedures in the development and evaluation of psychological measures (Floyd and Widaman, 1995). The factor analysis method is used to divide criteria into groups (Tzeng et al., 2007). Factor analysis is particularly useful with multi-item inventories designed to measure behavioral styles, cognitive schema, and other multifaceted constructs of interest to clinical psychologists (Floyd and Widaman, 1995). Assessing creative potential requires a focus on how and why an individual responds to activities (Kaufman et al., 2011). The behaviors that are related to the creative activity must be clearly stated and readily translated into the assessment (Amabile, 1983).

This study used three main factors. The first factor comes from the model proposed by Ruscio, Whitney, and Amabile (1998), to identify task motivation as a measure of involvement in tasks. Behaviors such as set breaking, task pace, exploration, enjoyment, and concentration are identified as the ways in which intrinsic motivation manifests itself within the creative process. Second, domain-relevant factors determine the initial set of pathways to search for a solution and the ability to verify an acceptable solution (Amabile, 1983) through assuredness, difficulty and exhibited uncertainty activities within gameplay. Third, the ability to break away from standard thinking, approaches and solutions during problem solving. Individuals can gain experiences from idea generation that may inform their own strategies (Amabile, 1996). Creativity-relevant skills are measured through the specific process factors of concrete focus, concept identification, wide focus and striving (Ruscio et al., 1998).

Methodology

The study methodology was broadly divided into two stages. The first stage involved a game study adapted from an existing creative potential method (Inchamnan et al., 2012). This creative potential method examines players by using established creativity criteria in order to determine the levels of creative activity. The process focused on the reliability of the factors used for measurement determining those factors that are more strongly related to creativity. The second stage involved the determination of relationships of game play elements. The objective of this stage was to investigate and establish related elements that supported creative performance and learning outcome.

To examine the creative process, participants were video recorded while playing the games and a video coding scheme was used to capture the type and frequency of observable behaviors and participant verbalizations. To assess the game experiences, this study used the 21-item PENS survey that consists of five dimensions: competency, autonomy, relatedness, presence, and intuitive controls. Each item consisted of statements on a seven-point scale ranging from 1 to 7. Specifically, the research reported in this paper examined the relationship between creative game play processes and game play experience as measured by the Player Experience of Need Satisfaction (PENS) survey: in-game competence; in-game autonomy; in-game Presence; in-game intuitive control and in-game relatedness. This paper examines the relationship between creative game play processes and game play mptivation experience as measured by the Player Experience of Need Satisfaction (PENS) survey:

- In game Competence. This scale measures participants' perception that the game provides a competency.

- In game Autonomy. This scale assesses the degree to which participants felt free, and perceived opportunities to do activities that are interested in them.

- In game Presence. This scale measures the sense of immersion in the gaming environment. Three items considered are: physical presence, emotional presence and narrative presence.

- In game Intuitive Control (IC). This scale assesses the degree which participants control their character's actions in the game environment.

- In game relatedness. This scale assesses the desire to connect with others in a way that they feel authentic and supportive.

Study Procedure

To explore the relationships between the uses of creative processes during game play and the player experiences, this study focused on four games, that is, Portal 2, I-Fluid, Gunz 2: The second Duel, and Braid. While these games had different mechanics, goals and settings, they all required the players to solve problems in the game tasks to progress through the game play. Evaluation methods involved examining the creative process as measured by task motivation, domain-relevant skills and creativity-relevant skills. Game task behaviors and verbalizations were coded to obtain the empirical indices of the creative processes in which game players were engaged. Participants (N=120) were observed during play of the four selected games. To examine the creative process, participants were video recorded while playing the games. A video coding scheme was used to capture the type and the frequency of the observable behaviors and verbalizations. This coding scheme was implemented based on the criteria below that were developed for analyzing creative process (Inchamnan, Wyeth, & Johnson, 2012). The results from stage 1 were used to establish the extent to which the games facilitated creativity and how the components of creativity were involved. A video coding scheme was used to capture the type and the frequency of the observable behaviors and verbalizations in which participants engaged. The coding used items that were identified as significant in the creative process (Ruscio et al., 1998). The coding was performed using both 7-point Likert scales and frequency counts.

In terms of learning, the pilot study included 15 students. The unit outcomes of participants during the study period were observed in order to evaluate logical skills (math and programming) and creative art skills (i.e., animation drawing). The study examined the impact of video games on the students' motivation and their school records: programming, math and art subjects. The participant group played the game Gun Z 2: The second, Duel online between their friends and Bots. In the experiments, gameplay finished in approximately 15 minutes in total and completed a Player Experience Needs Satisfaction (PENS) questionnaire (Przybylski et al., 2012) after playing.

Results

Factor Analysis of Creative Potential Game Activities

The levels of creative problem solving that occured during game play and the determination of the game design elements were necessary in facilitating creative game play. Objects and resource manipulation within the games were a source of behavior variation across all components. Table 2 shows the actual factors that were extracted from all 16 variables. In table 2, all factors account for 72.51 percent of the variability in all 16 variables.

The pilot testing of items performed to ensure a common construct are moderately correlated with one another and are correlated with the total scale score. If one item does not satisfy the moderate correlation constraint (e.g., $r \geq .20$) to other items in the construction process, that item tends to perform poorly in a factor analysis. Kaiser-Meyer > .5 (.789, n=120) is acceptable for this factor analysis technique.

Table 2. Behavioral Factor Total Variance Explained

Factor	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	6.231	38.947	38.947
2	2.470	15.439	54.386
3	1.618	10.110	64.495
4	1.282	8.012	72.508

Strong Factor Component

According to table 2, Factor 1 accounts for 38.95% of the variance value of all 16 variables. Ten variables that are loaded strongly on this factor are involvement (task), set breaking (task), pace (task), planning (task), playfulness (task), exploration (task), enjoyment (task), concentration (task), assuredness (domain), difficulty (domain) and wide focus (creative).

Table 3. Components Matrix of Creative Components

Component Matrix[a]				
	Factor			
Creative Component	1	2	3	4
Involvement (Task)	.753	-.257		-.131
Stability (Task)	.232	.705	.314	
Set breaking (Task)	.863			
Pace (Task)	.787	-.246		
Planning (Task)	.888	.149		.127
Playfulness (Task)	.830	.361	-.111	
Exploration (Task)	.843	.317		.111
Enjoyment (Task)	.804	.384		
Concentration (Task)	.790		.118	
Exhibited uncertainty (Domain)		.605	.569	
Assuredness (Domain)	.748	-.506		.185
Difficulty (Domain)	.298	-.461	.574	-.157
Wide focus (Creative)	.329		-.556	-.321
Striving (Creative)	-.257	.834		-.215
Concrete focusses (Creative)		.131	-.328	.860
Concept identification (Creative)	.248	.295	-.515	-.328

This issue regarding measured variables concerns the scale on which scores fall. Factor 1 finding refers to the player who can work on solving problems (involvement game activity). The game play gives players the opportunity to manipulate materials; uses or attaches them in new combinations (set breaking game activity). Speed while playing the game allows the participant to work on tasks/challenges (pace game activity), allows players to organize material, to establish an idea, and to order to build on (planning game activity). Playfulness (playfulness game activity) activities engage the player in tasks in a curious manner; trying out ideas in a carefree way and exploration (exploration game activity), being curious, or playful,

while testing out new ideas. The enjoyment (enjoyment game activity) refers to the fact that the player has a pleasant experience, finds pleasure in the task/challenge and focuses on the task; not distracted (concentration game activity).

The task motivation game activities relate to the learning domain-relevant skills during game play. The results in the domain-relevant skills categories might be expected. Players are confident: certainty of ability to complete tasks; assuredness in going about the task; not doubtful, timid, or anxious (assuredness game activity). The player faces the problems within the game activities and reflects on the game tasks by making a negative statement (difficulty game activity). The creative-relevant skill has a relationship between the effect of intrinsic motivation and domain-relevant skill required during game play activities. The creative-relevant skill allows the player to have a future oriented; restatement of the problem given, the self-imposed goal, and statement dealing with a desired final goal (wide focus).

Player Experiences Have an Influence on Creative Process Skills

The significant mean differences of PENS scores (player experience) across creative components shown in Table 4 point out that players felt competence during involvement in the game. The autonomy scale assesses the degree to which participants felt free, and perceived opportunities to do activities that interest them with striving. In game relatedness, the scale assesses the desire to connect with the others in a way that feels authentic and supportive.

These results show significant ($\alpha < .05$) player experiences that are significant to the concept identification within the game play. The intuitive control scale aims to assess the degree to which participants control their character's actions in the game environment. These results show significant ($\alpha < .05$) player experiences that were significant to the concept identification and striving within the game play activities. These findings show that player experiences have an influence on creative process skills.

Table 4. The significant mean differences of PENS scores across creative components

ANOVA Between Group	**Df.**	**F**	**Sig.**
Involvement and Competence	9	7.698	.018
Striving and Autonomy	9	5.301	.040
Concept identification and Relatedness	7	5.003	.025
Striving and Intuitive Control	10	6.587	.042
Concept identification and Intuitive Control	10	6.305	.045

Game Activities Encourage Efficient Learning

The significant mean differences of school record scores across creative components shown in Table 7 point out that players adjusted speed at particular tasks, in a slow to a fast gradient of task rate. The logical skills as programming subjects related how students organize game elements; establishes an idea, order to build in, and steps to take within game activities.

Table 5. The significant mean differences of school record and creative components

ANOVA Between Group	Df.	F	Sig.
Programming and Pace	5	4.104	.032
Programming and Planning	4	5.649	.012
Art and Concept Identification	8	4.406	.044

These results show significance ($\alpha < .05$) in the relationships between the Art subject and creative-relevant skill as concept identification within the game play activities. These findings show that game activities encourage learning in this domain.

Game Activities Facilitate the Creative Process During the Game Play Experience

The finding identifies (in Table 6) a significant ($\alpha < .05$) player experience of playing games that were coded with involvement (task motivation), exhibited uncertainly (domain-relevant skill) and concept identification (creative-relevant skill) within the game play. The programming and mathematics results aim to assess the degree that a player has logical thinking about learning. These results show a significant ($\alpha < .05$) playful learning that was signed with exploration, wide focus, and concept identification within the game play.

Table 6. The significant mean differences of PENS scores across creative components

ANOVA Between Group	Df.	F	Sig.
Involvement and Year of Game Experience	3	8.103	.004
Exploration and Programming	5	7.784	.004
Exhibited uncertainly and Year of Game Experience	3	5.721	.013
Concept identification and Year of Game Experience	3	14.707	.000
Wide focus and Math	4	6.424	.008
Concept identification and Programming	5	9.068	.003

Creative Potential and Learning Outcome

The creative-relevant skill encourages learning activity through the degree to which player has logical thinking of learning (involvement, concept identification and year of game experience). It appears that the ideal conditions for creativity are achieved within self-initiated backtracks by using intentional moves to previous locations or by revisiting a particular game task/challenge (exhibited uncertainly and year of game experience).

Table 7. The significant mean differences of PENS scores across creative components

ANOVA Between Group	Df.	F	Sig.
GPA and Competence	9	8.361	.015
GPA and Intuitive Control	10	5.977	.050

Table 7 shows a significant difference of learning outcome (GPA) within the players' feeling of competence and intuitive control during play games. These findings refer to game activities that can facilitate an individual's learning outcomes by using creative process skills.

Guidelines for Digital Game Based Learning

As aforementioned, the guidelines presented herein are used to assist game developers to produce games that facilitate creative problem solving. First, learning outcomes have to be mapped to the mechanisms of learning that are identified as facilitating creative potential. These conceptual guidelines are shown in figure 1 as an overview of the Creative Potential of Learning Model (CPLN). In the figure, one can see that all principle concepts are linked into the circular module. In order to clearly understand the interrelationships between principles of learning and creative potential, the interpretation of the results is indispensable. A game's ability to facilitate task motivation centers on the creation of an environment that instills confidence to complete tasks and ensures that players have logic skills to explore their experiences.

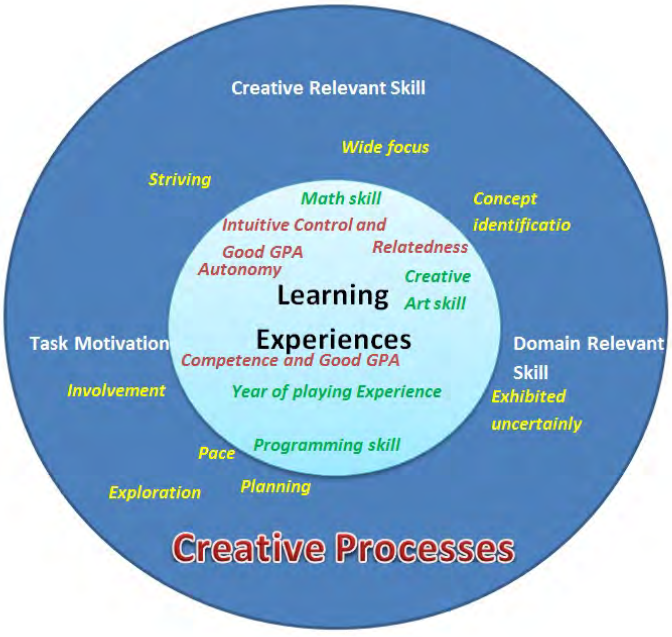

Figure 1. The Creative Potential of Learning Principles Model (CPLN)

Creativity-relevant skills provide greater opportunities for players to strive to engage in gameplay. This can be achieved by allowing activities such as Striving and Autonomy and Striving and Intuitive Control. The results refer to game activity experiences as intuitive control affects the learning outcome.

This can also be achieved by allowing activities that are future-oriented, to let players work through problems which require facilitating interactions with others, and require a feeling of intuitive control (concept identification and relatedness; concept identification and intuitive control). Creative-relevant skills encourage learning activities related to logic, such as concept identification and creative art skill, wide focus and math, and concept identification and programming.

The tension parameter has been identified between providing an experience that encourages striving (creative-relevant skills) and producing gameplay where the player finds it straight-forward to understand what they are required to do and how they might go about doing it (domain-relevant skills). In identifying processes, it appears that the ideal conditions for creativity are achieved within self-initiated backtracks by using intentional moves to previous locations or revisits of a particular game task/challenge (exhibited uncertainly and year of game experience).

Task motivation activities results showed that game challenges effectively allowed for cognitive and logical thinking and strategic planning. There were multiple types of challenges available that players could approach in their own way and at players' own pace. The level of challenge was well matched to player skill level.

The subsequent step of the producing a guideline is to map the game activity components to the mechanisms identified (Inchamnan et al., 2014), and learning skills in Figure 1. These guidelines are outlined below. Please notice that creative components which are facilitated are included in brackets.

- Ensure that the class includes clear goals that allow students to develop their own sub-goals and problem solving skills (wide focus, math skill).
- Create challenges in the class that require logical thinking, involvement and strategic planning in the class (complexity in problem solving, planning, refining problem solutions)
- Implement challenges that develop at an appropriate pace and match a student's skill level (facilitate striving activity, environments that instill feeling autonomy)
- Implement rules that offer freedom of choices, where students have the options about what actions to use to solve a problem in the class lesson (wide focus, object use and manipulation, planning)
- Manage student errors by allowing supports for the recovery from errors, and by ensuring that the impact is minimal (facilitate striving activity, environments that instill confidence)
- Allow students to receive immediate and continuous feedback on their actions (environments that instill competence, understand what is required, clear pathways to complete lesson)

Conclusion

This study examines the aspects of game playing that might help people learn more effectively. The study maps the results of the analysis of players engaging in creative problem solving during online game play. Data analysis helps us to better understand how in-game activities influence a player's engagement in creative activity and learning. Furthermore, this study developed preliminary guidelines. The guidelines consider the specific ways that game developers might align learning mechanisms to support creative problem solving processes.

The activities should provide involvement, exploration and planning. Players should be engaging problem solving skills, concept identification and wide focus. They should be striving, and exhibiting uncertainty.

Future studies should investigate the applicability of the Creative Potential of Learning Model to other game genres. Furthermore, the guidelines proposed in this study could be applied and evaluated in game development to support creative activity for educational purposes. Finally, future works could focus on larger samples in order to find out how games have the potential to help people to learn more effectively in terms of creative processes.

References

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of personality and social psychology, 45*, 357-376.

Amabile, T. M. (1996). *Creativity in context*. Boulder, Colorado. Westview Press Inc.

Clark, C. M., Veldman, D. J., & Thorpe, J. S. (1965). Convergent and divergent thinking abilities of talented adolescents. *Journal of Educational Psychology, 56*(3), 157-163.

Cooper, J. O. (1982). Applied behavior analysis in education. *Theory into practice, 21*, 114-118.

Cooper J. O, Heron T. E, Heward W. L. (2007). Applied behavior analysis (2nd ed.) Upper Saddle River, NJ: Pearson.

Floyd, F. J., & Widaman, K. F. (1995). Factor analysis in the development and refinement of clinical assessment instruments. *Psychological assessment, 7*(3), 286-299.

Gordon, W. J. J. (1961). *Synectics, the development of creative capacity.* New York: Collier.

Habgood, M. J., & Ainsworth, S. E. (2011). Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games. *The Journal of the Learning Sciences, 20*, 169-206.

Inchamnan, W., Wyeth, P., & Johnson, D. (2013). Does activity in computer game play have an impact on creative behaviour? Proceedings of the Games Innovation Conference (IGIC), 2013 IEEE International.

Inchamnan, W., Wyeth, P., & Johnson, D. (2014). Design for creative activity : A framework for analyzing the creative potential of computer games. Procedings of the Lecture Notes in Computer Science : Entertainment Computing.

Myers, J. L., Well, A. D., & Lorch, R. F. (2010). *Research design and statistical analysis*. New York: Routledge.

Paras, B., & Bizzocchi, J (2005, June*). Game, motivation, and effective learning: An integrated model for educational game design*. Paper presented at the International DiGRA Conference.

Perrotta, C., Featherstone, G., Aston, H. and Houghton, E. (2013). Game-based Learning: Latest Evidence and Future Directions (NFER Research Programme: Innovation in Education). Slough: NFER.

Prensky, M. (2002). The motivation of gameplay: The real twenty-first century learning revolution. *On the Horizon, 10*, 5-11.

Prensky, M. (2005). Complexity matters. *Educational Technology, 45*, 5-20.

Prensky, M. (2005). Computer games and learning: Digital game-based learning. *Handbook of computer game studies, 18*, 97-122.

Przybylski, A. K., Rigby, C. S., & Ryan, R. M. (2010). A motivational model of video game engagement. *Review of General Psychology, 14*(2), 154-166.

Przybylski, A. K., Weinstein, N., Murayama, K., Lynch, M. F., & Ryan, R. M. (2012). The ideal self at play: The appeal of video games that let you be all you can be. *Psychological science, 23*, 69-76.

Rigby, S., & Ryan, R. (2011). Glued to Games: How Video Games Draw Us in and Hold Us Spellbound. Santa Barbara, CA: Praeger.

Ruscio, J., Whitney, D. M., & Amabile, T. M. (1998). Looking inside the fishbowl of creativity: Verbal and behavioral predictors of creative performance. *Creativity Research Journal, 11*, 243-263.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist, 55*(1), 68-78.

Schaefer, C. E. (1969). The prediction of creative achievement from a biographical inventory. *Educational and Psychological Measurement, 29*, 431-437.

Shute, V. J. (2011). Stealth assessment in computer-based games to support learning. *Computer Games and Instruction, 55*, 503-524.

Spearman, C.E. (1930). *Creative mind.* New York: Cambridge.

Sviderskaya, N. (2011). The EEG spatial pattern and psychophysiological characteristics of divergent and convergent thinking in humans. *Human Physiology, 37*, 31-38.

Sweetser, P., & Johnson, D. (2004). Player-centered game environments: Assessing player opinions, experiences, and issues. Entertainment Computing–Proceedings from the ICEC.

Turcsányi-Szabó, M., Bedő, A., & Pluhár, Z. (2006). Case study of a team challenge game—e-PBL revisited. *Education and Information Technologies, 11*, 341-355.

Tzeng, G. H., Chiang, C. H., & Li, C. W. (2007). Evaluating intertwined effects in e-learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert Systems with Applications, 32*, 1028-1044.

Appendix 1. Example of School Record

Subject	Cr./Grade/Point	Subject	Cr./Grade/Point
General Education 30 Credits		GT203 Drawing for Animation & Game Develop	3/A /12.0
Humanities 6 Credits		GT204 Computer Programming Concepts	3/C+/7.5
Humanities Mandatory 3 Credits		GT205 Game Concepts and Design	3/A /12.0
GE120 Physical Education for Quality of Life	1/A /4.0	GT206 Mythology and Game Development	3/A /12.0
GE139 Holistic Approaches to Life	1/A /4.0	GT207 Laws & Ethical Issues in Game Dev. Prof.	3/A /12.0
IL103 Information for Research	1/A /4.0	GT208 Business Model Writing for Interactive ai	3/B+/10.5
Humanities Selective 3 Credits		LA201 English for Specific Purposes 1	3/D+/4.5
GE121 Man and Reasoning	3/__/____	LA202 English for Specific Purposes 2	3/D+/4.5
GE122 Philosophy and Life	3/A /12.0	Major Courses 45 Credits	
GE123 Thai Studies	3/__/____	FA209 Drawing 2	3/B /9.0
GE124 Thai Folk Wisdom	3/__/____	GD303 Introduction to Graphic Design	3/B /9.0
GE131 World Civilization	3/__/____	GD304 Typography 1	3/B+/10.5
Social Sciences 9 Credits		GT301 Digital Storyboard	3/B /9.0
Social Sciences Mandatory 6 Credits		GT302 Computer Graphic and Animation	3/A /12.0
BA102 Business Analysis and Planning	3/C+/7.5	GT303 Digital Character Modeling	3/A /12.0
LW102 Introduction to the Study of Laws	3/C /6.0	GT304 Game Interface Design	3/A /12.0
Social Sciences Selective 3 Credits		GT305 Digital Objects and Tools Design	3/A /12.0
BA101 Managing Business for New Entrepreneur	3/__/____	GT306 Environment and Level Design	3/B+/10.5
GE125 Politics, Economy, and Society	3/__/____	GT307 Digital Audio & Video for Game Product	3/B+/10.5
GE126 Psychology for Quality of Life	3/B+/10.5	GT308 Project Management for Game Productic	3/A /12.0
GE137 Public Mind for Community	3/__/____	GT309 Game Engine	3/A /12.0
Sciences and Mathematics 6 Credits		GT310 Game Design Criticism and Analysis	3/A /12.0
MA103 Mathematics and Statistic for Daily Life	3/C /6.0	GT311 Game Development Project 1	3/B+/10.5
SC103 Science and Technology for Quality of Life a	3/B /9.0	GT312 Game Development Project 2	3/A /12.0
Languages 9 Credits		Elective Courses 15 Credits	
LA010 Remedial English	-/S /0.0	AD301 Advertising and Consumer Behavior	3/__/____
LA101 English 1	3/D+/4.5	BT321 Digital Imaging	3/__/____
LA102 English 2	3/C /6.0	BT322 Digital Photography	3/__/____
TH103 Communication Skill in Thai	3/C+/7.5	BT323 Multimedia Business	3/__/____
Core Courses 42 Credits		BT345 Graphic Design for Web Site	3/B+/10.5
FA201 Art Aesthetic	3/B+/10.5	BT401 Directed Study	3/__/____
FA205 Thai Art	3/B /9.0	BT402 Special Topic in Multimedia System	3/__/____
FA207 Art Composition	3/A /12.0	GT351 Digital Lighting and Camera Technique	3/A /12.0
FA208 Drawing 1	3/B+/10.5	GT352 Texture Rendering Technique	3/A /12.0
GT201 Intro.to Interactive Design & Game Develo	3/B /9.0	GT353 Interactive Web Site Design	3/C /6.0
GT202 Mathematics for Game Developers	3/C /6.0	GT354 Protfolio Development	3/__/____

Subject	Cr./Grade/Point	Subject	Cr./Grade/Point
GT355 C Programming	3/__/____		
GT356 C ++ Programming	3/__/____		
GT357 2D Game Programming	3/__/____		
GT358 3D Game Programming	3/__/____		
GT410 Co-operative Education	6/A /24.0		
IT207 Electronic Business	3/A /12.0		
MK201 Principles of Marketing	3/__/____		
วิชาหมวดเลือกเสรี			
	0/__/____		

Present :	Total Credits	:	138	Credits.	Cumulative Points	:	454.50 Points
	Credits Earned	:	138	Credits.	Grade Point Average	:	3.29 Points

Appendix 2. The Pens Questionnaire

ID_____

PENS	1= Do Not Agree(ไม่เห็นด้วย), 7=Strongly Agree(เห็นด้วย) 1 2 3 4 5 6 7
PENS: Competence C1. I feel competent at the game. ผู้เล่นรู้สึกเชื่อมั่นว่าสามารถเล่นเกมได้	
C2. I feel very capable and effective when playing. ผู้เล่นรู้สึกว่าสามารถเล่นเกมได้ดีและมีประสิทธิภาพ	
C3. My ability to play the game is well matched with the game's challenges ความสามารถของผู้เล่นเหมาะสมกับด่านต่างๆในเกม	
PENS: Autonomy A1. The game provides me with interesting options and choices ในเกมเตรียมทางเลือกต่างๆ ให้ผู้เล่นอย่างน่าสนใจ	
A2. The game lets you do interesting things เกมให้ผู้เล่นรู้สึกสนใจที่จะเล่นเกม	
A3. I experienced a lot of freedom in the game ประสบการณ์ในเกมรู้สึกผู้เล่นมีอิสระในการเล่น	
PENS: Relatedness R1. I find the relationships I form in this game fulfilling. ผู้เล่นรู้สึกมีความสัมพันธ์กับเกมและเติมเต็มผู้เล่น	
R2. I find the relationships I form in this game important. ผู้เล่นรู้สึกมีความสัมพันธ์กับเกมมีความสำคัญ	
R3. I don't feel close to other players. (-) ผู้เล่นรู้สึกไม่รู้สึกใกล้ชิดกับผู้เล่นคนอื่น	
Presence/Immersion P1. When playing the game, I feel transported to another time and place. ขณะเล่นเกมผู้เล่นรู้สึกปิติยินดีในช่วงเวลาและสถานที่นั้นๆในเกม	

P2. Exploring the game world feels like taking an actual trip to a new place. การท่องและค้นหาในเกมผู้เล่นรู้สึกเหมือนได้ไปในสถานที่ใหม่ๆ							
P3. When moving through the game world, I feel as if I am actually there. ในขณะที่ผู้เล่นท่องไปในโลกของเกมผู้เล่นรู้สึกเหมือนอยู่ ณ ที่นั้นๆ จริงๆ							
P4. I am not impacted emotionally by events in the game (-). เหตุการณ์ในเกมไม่มีผลกระทบต่อจิตใจของผู้เล่น							
P5. The game was emotionally engaging. เกมโน้มน้าวใจผู้เล่น							
P6. I experience feelings as deeply in the game as I have in real life. ผู้เล่นรู้สึกว่าเกมเหมือนในชีวิตอย่างมาก							
P7. When playing the game I feel as if I was part of the story. ผู้เล่นรู้สึกว่าเป็นส่วนหนึ่งของเนื้อเรื่องในเกม							
P8. When I accomplished something in the game I experienced genuine pride. ประสบการณ์ในการเล่นเกมทำให้ผู้เล่นมีความภาคภูมิใจที่สามารถเล่นและแก้ปัญหาภายในเกมได้							
P9. I had reactions to events and characters in the game as if they were real. ผู้เล่นตอบสนองเหตุการณ์และตัวละครภายในเกมเหมือนในชีวิตจริง							
PENS: Intuitive Controls: I1. Learning the game controls was easy. สามารถเรียนรู้การควบคุมเกมได้ง่าย							
I2. The game controls are intuitive. การจัดการในเกมสร้างความคิดริเริ่มให้กับผู้เล่น							
I3. When I wanted to do something in the game, it was easy to remember the corresponding control. เมื่อผู้เล่นต้องการจะทำอะไรบ้างอย่างในเกมสามารถทำได้สะดวกเนื่องจากอุปกรณ์ควบคุมในเกมสอดคล้องกัน							

Appendix 3. Observations Checklist

Participant number_____

Part 1

Coding Strongly disagree - > Strongly agree (1,2,3,4,5,6,7)	**CODE**	**(1-7)**
1. ผู้เล่นพยายามแก้ปัญหาภายในกิจกรรมในเกม **(**Participant works on solving problems within the game. **[**involvement]	**A11**	
2. ผู้เล่นเสียสมาธิหรือมีสิ่งรบกวนเพียงเล็กน้อยในขณะแก้ปัญหาThere is minimal distraction from solving problems in the game. **[**concentration]	**A21**	
3. ผู้เล่นสนใจแต่ภารกิจในเกมParticipant becomes focused on the tasks in the game. [concentration]	**A22**	
4. ผู้เล่นสามารถปรับดุลความสเถียรภาพของปัญหาภายในเกมParticipant can work on refining the integrity or stability of a problem solution within the game. [stability]	**A31**	
5. อ็อบเจกต์ และ เครื่องมือในเกมพร้อมให้ผู้เล่นใช้ได้อย่างเหมาะสมIn-game objects and materials are able to be readily manipulated. [set breaking]	**A41**	
6. ผู้เล่นสามารถปรับอ็อบเจกต์ และ เครื่องมือในเกมตามแนวทางของตนเองเพื่อบรรลุวัตถุประสงค์เบื้องต้นในเกมParticipant manipulates objects and materials that can be used in different ways to the primary purpose. [set breaking]	**A42**	
7. ผู้เล่นสามารถเร่งความเร็วจากช้าไปเร็วตามระดับภายในเกมThe speed at which participant is required to interact within the game progresses from a slow to fast gradient of working rate. [pace]	**A51**	
8. การวางแผนคือส่วนสำคัญในการเล่นเกมPlanning is an important part of game play. [planning]	**A61**	
9. เกมขึ้นอยู่กับการจัดการภายในเกมThe game relies on the organization or manipulate of objects as a part of game play. [planning]	**A62**	
10. ผู้เล่นสร้างแนวความคิดของตนเองได้ขณะเล่นเกมParticipant is able to establish ideas within the game. [planning]	**A63**	
11. ผู้เล่นสามารถวางแผนเป็นขั้นเป็นตอนขณะเล่นเกมParticipant can plan the order of actions and steps to take within the game. [planning]	**A64**	
12. ผู้เล่นรู้สึกอยากรู้อยากเห็นขณะเล่นเกมParticipant can engage in game tasks in a curious manner. [playfulness]	**A71**	
13. เกมสามารถตอบสนองการลองคิดสิ่งใหม่ๆ หรือทดลองแนวคิดของผู้เล่นได้The game provides opportunities to try out ideas in a carefree way. [playfulness]	**A72**	
14. ความอยากรู้อยากเห็นทำให้ผู้เล่นค้นหาแนวทางต่างๆภ่ยในเกมCuriosity during game exploration is encouraged. [exploration]	**A81**	
15. เกมสนับสนุนการทดทองแนวคิดของผู้เล่นThe game encourages playful testing out of ideas. [exploration]	**A82**	
16. ผู้เล่นรู้สึกเป็นช่วงเวลาที่ดีในการเล่นเกมThe game allows players to have a good time. [Enjoyment]	**A91**	
17. กิจกรรมในเกมสร้างความสนุกGame play tasks are pleasurable. [Enjoyment]	**A92**	

18. เกมให้ผู้เล่นรู้สึกมั่นใจในการเล่นThe game allows participant to feel assured in going about required tasks. [Assuredness]	**B11**	
19. ผู้เล่นรู้สึกมีความสามารถในการเล่นได้ดีParticipant feels certain about his/her ability to complete tasks in the game. [Assuredness]	**B12**	
20. ผู้เล่นสามารถเดากิจกรรมต่างๆได้ภายในเกมขณะเล่นParticipant demonstrates little doubt about what she/he required to do during the game play [Assuredness]	**B13**	
21. ผู้เล่นไม่รู้สึกท้อแท้ขณะเล่นParticipant doesn't feel anxious or timid as participant plays the game. [Assuredness]	**B14**	
22. ผู้เล่นเผชิญปัญหาภายในเกมขณะเล่นเกมParticipant encounters problems as participant plays the game. [Assuredness (-)]	**B15**	
23. กิจกรรมภายในเกมยากต่อการเล่นของผู้เล่นIt was difficult to complete tasks in the game. [Assuredness (-)]	**B16**	
24. มีความยากในการจัดการกับ **Object** ในเกมIt was difficult to work with the objects/resources in the game. [Assuredness (-)]	**B17**	

Part 2

Coding	**CODE**	นับครั้ง
25. ผู้เล่นย้อน ยกเลิกกิจกรรมบางกิจกรรมในเกมParticipant reverses or undoes steps/actions performed in the game. [exhibited uncertainty (-)]	**B21**	
26. ผู้เล่นรู้สึกไม่มั่นใจที่จะสามารถเล่นเกมได้จนผ่านเสร็จParticipant feels uncertain completing tasks in the game. [difficulty (-)]	**B31**	
27. ผู้เล่นรู้สึกสามารถเดากิจกรรมในเกมได้Participant has feelings of self-doubt while playing the game. [difficulty (-)]	**B32**	
28. ผู้เล่นส่งเสียงในทางลบขณะเล่นเกมParticipant produces negative statements about his/her ability as participants play the game. [difficulty (-)]	**B33**	
29. ผู้เล่นส่งเสียงที่แสดงไม่พอใจกับเกมParticipant produces negative exclamations (e.g. curses) as participant plays the game. [difficulty (-)]	**B34**	

Part 3

Coding Strongly disagree - > Strongly agree (1,2,3,4,5,6,7)	**CODE**	1-7
30. ผู้เล่นเผชิญปัญหาภายในเกมขณะเล่นให้ผ่านแต่ละด่านParticipant encountered problems while completing tasks in the game. [Striving]	**B41**	
31. ผู้เล่นมีอุปสรรค์ในการผ่านด่านต่างๆParticipant encountered obstacles while completing tasks in the game. [Striving]	**B42**	
32. ผู้เล่นมีคำถามที่จะผ่านแต่ละด่านParticipant questions what to do at particular stages in the game. [Striving]	**B43**	

Part 4

Coding	**CODE**	นับครั้ง
33 ผู้เล่นแก้ปัญกาที่ละด่านโดยแก้ปัญหาที่ละจุดจนกว่าจะสำเร็จThe current problem that needs to be solved in the game requires more than one step. [wide focus]	**C11**	
34 ปัญหาที่พบแต่จะจุดเป็นการนำไปสู่การแก้ปัญหาด่านต่อไปThe current problem in the game is future oriented. [wide focus]	**C12**	
35 ผู้เล่นกลับมาแก้ปัญหาเก่าที่ผ่านมาหลังจากที่ผ่านบางจุดไปแล้วParticipant restates the problem presented by the game. [wide focus]	**C13**	
36 ผู้เล่นสามารถพัฒนาวัตถุประสงค์ของตัวเองได้ในขณะเล่นParticipant is able to develop his/her own goals within the game. [wide focus]	**C14**	
37 ผู้เล่นทำบางอย่างที่ไม่เกี่ยวกับกิจกรรมในเกมParticipant is performing actions not related to game tasks/goals. [wide focus]	**C15**	
38 ผู้เล่นเปลี่ยนกิจกรรมหรือทำบางอย่างขณะเล่นเกมParticipant transitions to a new topic area or action in the game. [Striving]	**C21**	
39 ผู้เล่นรู้สึกสงสัยว่าจะผ่านแต่ละด่านอย่างไรParticipant questioned how to complete tasks in the game. [Striving]	**C22**	
40 ผู้เล่นสงสัยว่าตอนนี้กำลังทำอะไรอยู่Participant questions his/her current actions in the game. [Striving]	**C23**	
41 ผู้เล่นพูดหรือทวนคำพูดบางอย่างตามเหมือนที่เกมพูดParticipant repeats instructions, words or concepts presented in the game. [Striving]	**C24**	
42 ผู้เล่นควนคราง คำพูดบางอย่างในเกมParticipant makes exclamations, as a positive or negative outburst. [Striving]	**C25**	
43 ผู้เล้นพูดว่าชอบหรือไม่ชอบเกมParticipant makes statements of like or dislike about game tasks. [Concrete focus]	**C31**	
44 ผู้เล่นพูดถึงคุณภาพของเกมในเรื่องการออกแบบParticipant talks about the qualities of the materials, objects or attributes of the game world. [Concrete focus (-)]	**C32**	
45 ผู้เล่นบรรยายการเล่น กิจกรรม หรือประโยคต่างๆในเกมParticipant describes action/tasks/goals in terms of analogies or metaphors. [Concept identification]	**C41**	
46 ผู้เล่นอุทานออกมาขณะเล่นเกมParticipant had eureka-type moments in the game. [Concept identification]	**C42**	
47 ผู้เล่นหยุด เปลี่ยนกิจกรรมบางอย่างเพื่อให้เล่นเกมได้Participant has an abrupt change in activity designed to help complete a task. [Concept identification]	**C43**	