Evaluation of 3 Pedagogical Theories and Their Implications for Digital Game Based Learning

Abstract

“Over the past few years, several research projects, organizations, centers, grants, books, and studies have emerged exploring new visions for game based technologies in learning” (Squire, 2005). This paper will explore three pedagogical theories and their implications for digital game based learning (DGBL). An example of how this can be applied to an instructional design plan for a web graphics course utilizing DGBL methods that incorporate such theories is included.

Introduction

The use of game-based technologies in learning over the past few years has been a drawing interest and attention for many research centers and study organizations. The exploration has resulted in new visions emerging for learning interventions using games, also known as Digital Game-Based Learning (DGBL) models or methods (Squire, 2005). This paper will explore three pedagogical theories, (a) Gardner's theory of multiple intelligences, (b) Gagné's conditions of learning theories in relation to the nine events and learning hierarchies and (c) Bruner's discovery learning theories, and their implications for DGBL. The definition of DGBL and its characteristics will first be presented followed by a brief overview of information processing or cognitive processes that relates to learning and foundational concepts of the pedagogical theories. Finally, the paper will present an instructional design plan justified for a web graphics course on color theory principles utilizing DGBL methods with the theoretical implications.

What is Digital Game-Based Learning?

According on Prensky (2001), Digital Game-based learning (DGBL) is "any marriage of educational content and computer games" (p. 145). In an educational environment, the use of digital computer games offers the acquisition of knowledge construction opportunities (Garcia, 2005). Game-based learning emerged as a generic name for use of games in education. Most game-base learning embedded into curricular content builds upon the argument that lessons incorporating games contribute to the fun factor in learning (Begg, Dewhurst & Macleod, 2005). Gaming is also considered an activity that is interactive, entertaining and can make learning enjoyable (Aldrich, 2004; Schunk, 2004; Smaldino, Russell, Heinich, & Molenda, 2005). Besides that, games can engage critical thinking through problem solving skills (Schunk). Well-

designed games can intrinsically motivate learners to spend more time and effort with processing information during game play (Alessi & Trollip, 2001).

Gaming activities involve willing or losing, multiple players, dealing with rules, competition, reward or penalties, fantasy, taking turns and equipment (Alessi & Trollip, 2001). As an approach to instruction, Olsen, Dorsey & Reigeluth (1988) defines the term game "an instructional activity in which participants follow prescribed rules that differ from those of reality as they strive to attain a challenging goal, is usually competitive" (as cited in Reigeluth, 1999a, p.22).

The use of multimedia elements forms an important component for building game content. Multimedia is a combination of media that comprises of images, sound, video, animation and/or text supported through technology (Alessi & Trollip, 2001; Roblyer, 2006; Schunk, 2004). Application products such as games, utilize the components of multimedia for interactivity. The quality of the product (instructional resource) is dependant on the key element of design efforts that integrate multimedia elements for interactivity. Games employ a higher level of interactive design compared to the simple "point and click" events (Sims, 1997). Battaiola, Elias, and Domingues (2002) also referred computer games as interface modules made up of high levels of interactivity utilizing several integrated media. At a conference proceeding, they explicitly stated that, "computer games are examples of multimedia software with entertainment and high sophistication characteristics. Such technology allied with cognitive concepts can be used to implement educational software" (p. 1). Educational games can range from simple genre types such as card games, puzzles and matching games, to complex ones like adventures, role-playing games and simulations. The variety of genre types offers different forms of interactivity and engagement that relates to the development of cognitive processes.

Information Processing Related to the Pedagogical Theories in DGBL

Information processing (IP) theories focus on "attention, perception, encoding, storage, and retrieval of knowledge" (Schunk, 2004, p. 188). Information processing also known as cognitive processing, according to Schunk (p. 136), is a general term applied to theoretical perspectives that deals with the sequential order and the functioning of cognitive events; therefore, "it is not a name of a single theory" (see Figure 7). Theories such as Gardner's theories of multiple intelligences, Gagné's conditions for learning, and Bruner's discovery learning theories contains aspects of how various cognitive processes contribute to the paradigm of learning pedagogy and outcomes. Implications on how these theories relates to DGBL will be explored in the following sections.

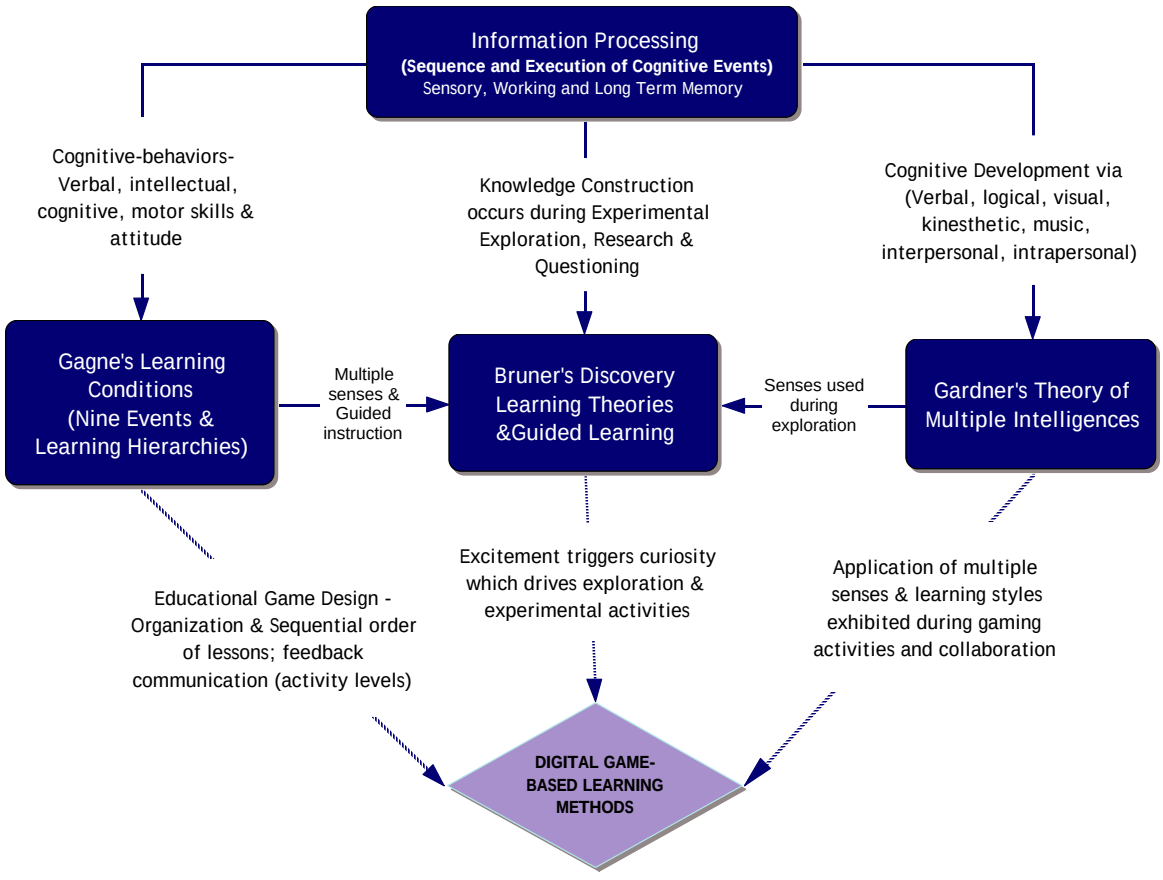

Figure 4. Implication of pedagogical theories for DGBL methods.

The use of multimedia games can foster the cognitive processes of selection (images and words), organization and integration (activate and integrate prior knowledge with incoming material and arranging information in a coherent manner) and meaningful learning (supported with guidance and reflection through interactivity) (Moreno & Mayer, 2005).

Cognitive processing is based on the working of three important components, the sensory memory, working-memory and long-term memory. The learning process involves the transformation of content (text, audio, static or animated visuals) from the environment into new knowledge and skills in memory, and then retrieved when needed. Content is first briefly stored in the sensory memory (the entry level for data processing) and then transferred to the working memory. The powerhouse for storage and processing information is the working memory (short-term memory). The working memory has limited capacity for cognitive load as well a short life span. For this reason, lessons delivered must be delivered in short segments. The center of learning also takes place in the working memory. The cognitive processes involve executing, managing and manipulation of data. Temporary stored data is then moved and stored in the long-term memory through organization and repetition of information processing from the working memory. For example, knowledge built from repeated practice drills and quizzes is transferred to the long-term memory. Information is then retrieved (encoding process) when needed (Clark, 2003; Lohr, 2003).

Gardner's Theory of Multiple Intelligences

The theory of multiple intelligences (learning involving multiple senses) developed by Howard Gardner suggests that there are at least seven ways how the process of learning takes place (Gardner, 1993). Gardner's elements of multiple intelligences play an important role in the innate process of cognitive development: verbal-linguistic, the application of words and

language, logical-mathematical, visual-spatial, body-kinesthetic, musical-rhythmic, interpersonal, and intrapersonal (Roblyer, 2006).

In a technology environment, this theory can apply to group work where students are assigned based on their intelligence type. For instance, students can have different roles in creating a multimedia project, such as create music (musical-rhythmic), design graphics (visual-spatial) or coding web pages (logical). As each student collaborates and shares skills with one another on various tasks, learning takes place during the interactive activities (Roblyer, 2006). Likewise, in game play scenario (challenge or competition), students with different form of intelligences in a group situation can team up and strategically work together. Becker (2005) offers the following observations in her analysis on how Gardner's theory relates to gaming activities, a good (well designed) game (a) includes words in the form of written and spoken elements included as direction and guidance; (b) presents logical processing involving mathematical intelligences available as scores, and also calculations for strategic moves; (c) offers spatial representation (cognitive) supported by high and rich visuals in the form or static or motion graphics (2D and/or 3D); (d) incorporates music with sound-effects embedded to enhance and communicate action events as well as feedbacks during games; (e) employs kinesthetic functions by referring to the virtual placement of the player in the game, where controls are manipulated by hand movements accompanied by music, visual and linguistic stimulation; (f) has an interpersonal component which involves motivation and team collaboration in competition while dealing with problem-based challenges; and (g) recommends the intrapersonal element which refers to emotional involvement (self-esteem) during the gaming activity.

Several of Becker's observations were also supported by Calvo's (1997) assertion that games can enhance intellectual development (understanding how things work, problem-solving

and devising strategies) through motor development where actions are controlled by precision coordination of speed and movement. As an affective and social development component, games can help stimulate understanding of life experiences, society's values and attitudes through fictional and role-playing situations (as cited in Gros, 2003). In a research conducted by Amory, Naiker, Vincent & Adams (1999), it was also found that students considered games that incorporate senses related to logic, memory, visualization and problem solving is crucial and required during the learning process. Each of the examples shown above exhibits various forms of learning involving multiple senses that is supported by the implications of Gardner's theories.

Gagné's Condition of Learning Theories (Nine Events of Instruction and Learning Hierarchies)

Gagne's conditions of learning outcomes: (a) verbal information (includes rote learning); (b) intellectual skills (example, problem solving in higher order skills); (c) cognitive strategies, (d) motor skills and (e) attitude (Schunk, 2004). The application of learning involving multiple senses bears similarities to Gardner's multiple intelligence theories. However, Gagne used these outcomes to help develop guidelines for arranging optimal conditions of learning. The set of guidelines refers to his nine events of instruction and learning hierarchies (Becker, 2005; Roblyer, 2005; Schunk, 2004). This bears important pedagogical and theoretical implications for planning instruction using DGBL methods.

Gagné's nine events of instruction stated by Becker supports the conditions for learning through media organization and selection. This affects how students learn and process information. Internal events refer to the learner's current capabilities, personal inclinations and ways of processing information while external events are instructional factors such as material selection and mode of presentation that supports learning. The use of learning hierarchies stated by Schunk on the other hand specifies component skills with prerequisite requirements. Gagne's

hierarchy concept is helpful for establishing strategies while designing pedagogic objectives (Carswell & Benyon, 1996).

Gagne's nine events of instruction, gaining attention, inform learners of objectives, stimulating recall of prior learning, presenting the stimulus, providing learner guidance, eliciting performance, providing feedback, assessing performance and enhancing retention and transfer (Driscoll, 2000) can be found in games for learning (Becker, 2005). Organization and presentation through screen design plays a role in gaining attention and influences how learners process information (Deubel. 2003). Chunking of information (layout of text and images) is important. As discussed earlier in information processing, the working memory has capacity limitation and a short life span (Clark, 2003). Stemler (1997) states that information must therefore be delivered in manageable segments of small chunks during the learning process (as cited in Deubel).

Game introductions, a form of attraction builder (the initial "set-up") supported though the use of multimedia serve as an important element to gaining attention (Becker, 2005; Bill, 1997). This relates to Gagne's first event for learning. Deubel (2003) also suggested the use of design elements such as colors, arrows and animations as attention directors for gaining attention. The presentation of objectives and goals in game activities is to inform learners of the desired outcomes for the gaming activity (Bill, 1997). In addition, learning objectives in a game scenario defined by Becker (2005) pertains to information given to the player that encompasses the back-story (history and elements of the story in the game) and descriptions on how one gets to be the winner for the game.

The application of Gagne's stimulation of prior learning can be found in the following example. The use of levels in gaming activity stated by Becker, often times provides a frame of

reference to a previous level including the introduction, hence supporting prior learning concepts. When presenting new information, the learner can remember the new information better if learning is connected with already known information ("repeated information") or previous experience (Clark, 2003; Lohr, 2003).

Games also function like tutors and learning how to play can be taught within the game itself. The programming in the game thus provides learning guidance. For example, Gagne's event in feedback recommendation as reinforcement as well as performance assessment are provided in a variety of ways such as scores, queries, audio, visual and text displays. The programmed feedbacks form as a communication tool to inform learners of their progress in relation to the various game levels and challenges. The enhancement of knowledge retention and transfer is also achieved through level application where learners are required to remember skills, knowledge and strategies from previous levels (Becker, 2005). In addition, games present opportunities for learners to repeat activities, thus encouraging the activity for rehearsal. The pedagogic value of learner control in rehearsal performance can help and reinforce the process of learning (Deubel, 2003).

Discovery Learning

Bruner's discovery learning, a type of inductive learning stated by Schunk (2004) purports exploration, experimentation, working on research, asking questions and looking for answers (Alessi & Trollip, 2001). It is based on the assumption that knowledge is acquired or constructed during observations and the unstructured learning activities. Learners are responsible for their own learning. The theory also emphasizes on higher order thinking skills and focuses on intrinsic motivation that can assist learners in remembering facts during the discovery (Gilanni, 2003; Roblyer, 2006). However, Gillani and Roblyer presented that structured experience (with

knowledge pre-requisites) should be provided first and the activity should be part of the guided instruction. Prior researchers support and advocate instructor-based guidance; they believe that the guidance creates meaningful learning for participants in discovery learning environments that engages interactivity (Mayer & Moreno, 2005). This guided notion is also supported by Alessi and Trollip, and Schunk. In relation to cognition processing noted by Schunk, the learning of facts, concepts and principles are supported if the constructs of new information are arranged in an organized (guiding implications) manner.

In DGBL modules, the process of discovery learning allows the learners to have the ability of selecting lessons at their own pace. They also have control over their learning process and skills (example selection of increasing levels of difficulty). The supplementation of immediate programmed feedback and progress during the gaming activity allows guided discovery learning to take place as part of the learning process. Examples of discovery learning and guided discovery are often found in problem-based scenarios or adventure games (Deubel, 2006). Simulation games contain “play objects, rules, and roles that reflect real-world objects and processes” (Thiagarajan, 2005, p. 235). De Jong & van Joolingen (1998) asserts that simulations used as examples of problem-solving activities are well suited for discovery learning because students are involved “deep” (intuitive) cognitive processing (as cited in Schunk, 2004). The learners have to reflect, consider options incorporating strategies that forms important components of the learning process (Deubel).

Based on the exploration on pedagogical theories and their implications for DGBL, it appears that the theories of Gardner, Gagné and Bruner’s theories can be applied differently depending on the genre type for the game. The levels of cognitive processing applications were

also found to work differently. Examples of how these games incorporated into a web graphics course that can help support learning outcomes will be discussed in the following section.

An Instructional Design Plan Development and Justification for a Web Graphics Course Utilizing DGBL Methods

An online web graphics course incorporating DGBL methods focusing on the teaching of color design principles will be implemented in a community college setting. The students comprise of dual credit high school students and adults from a variety of orientation, ethnicity, career and educational backgrounds. The introductory color design course will explore elements of color theory and application concepts in web design. Course goals and objectives will include: (a) basic terms and vocabulary in color theory; (b) color mixing and harmonic relationships; (c) dimensions of hue, value, shades, tints, and intensity; and (d) historical and color implications related to culture, emotion, religion, society and environment.

Scenario Overview – Defining the Need for DGBL

Traditional teaching approaches using digital printed and simple PowerPoint presentations followed by discussion questions and project based activities make up the major component for previous course deliveries. Based on semester course observations, performance work from assignment and project presentations exhibited a constant lack of proper color application, use of vocabulary words and related concept terminology. Formative and summative evaluations revealed that the students struggled with the assigned readings from the text-based lectures and materials. They complained that the reading assignments were too boring and non-engaging. Suggested ideas such as the use of videos, animation and multimedia interactions (programmed) instead of text-based materials were recommended. After much discussion and research, the faculty members agreed that increase motivation and content engagement via the

use of games should be implemented for the course. The interactive games must also align with course objectives and learning outcomes.

Revision of Course Design –Development and Design Process

The course will contain all the elements of previous course materials with the new addition of DGBL modules. Gros (2003) states that one of the greatest difficulties in using games in an education environment is finding room to incorporate the game into the curriculum effectively. In addition, time and effort is required to develop highly interactive games such as adventures and stimulations (Alessi & Trollip, 2001). Hence, as starters, simpler game models should be used as recommended by Gros.

The DGBL modules will function as a complementary tool to the class. The use of multimedia-based (video and audio) tutorial lessons will precede each game. Three examples of game modules: (a) practice drills (example, matching game); (b) puzzles (example, crossword puzzles); and (c) email games and will be used during the implementation. These games will be created using cost effective and user-friendly applications. In addition, learning objectives and supporting theoretical implications for learning will also be the focus during the development and design process.

Drill-and-practice. Tasks such as studying fact-based information and the building of vocabulary terms can supported through drill-and-practice approach where the learner's progress and feedback is available (Smaldino, Russell, Heinich, & Molenda, 2005). Brownfield & Vik (1983) and Ricci (1994) defined practice drills as repeated exercises that can promote knowledge, acquisition and retention (as cited in Mitchell & Savill-Smith, 2004). In addition, competition, team play, display and response variety, goal setting and scoring can be incorporated into practice drill exercises as part of the gaming activity (Alessi & Trollip, 2001).

As an example on how this game genre can fit into the web graphics course, the following section will describe a drill-and-practice game using matching answers as the focus for learning vocabulary and concept terms on color theory. The goal and objective of the game is to know and master as set of vocabulary and concept terms pertaining to color design by the end of each level. Learners will be required to match the correct color term to its definition. They also have to complete the set of exercise drills (10 questions utilizing the display of text and/or graphics) within a given a given time frame for each level (example, Level 1: 4 minutes seconds; Level 2: 3 minutes. and Level 3: 2 minutes). The questions will be displayed one at a time from a random pool of questions. As each question is displayed, the learner will click on the matching answer. Meanwhile, the program will monitor and record the speed and score of answer selections. Learners will be able to observe the progress the display panel.

The learners must be able to answer all 10 questions within the 4-minute time limit; otherwise, the player will have to start over. At the end of each sequence, the program will also show the learner the results of the game supported with explanation for incorrect answers. The feedback will help inform the learner on areas that need improvement. They will also have the option of repeating a game to get a better score or review the module for personal practice. Motivated learners have a choice of proceeding on to higher challenging options (Level 2 or 3); that is completing the game within a shorter time limit. While trying to accomplish the goals of the game by attaining the highest score or beating each level, the practice can help with memorization of color vocabulary and concept terms. Upon mastering the various terms, the learner can now proceed to another genre of game that utilizes the learned vocabulary; this time with a different learning application.

Puzzles. Puzzle tasks contain rules of operation prior to engagement. They have an obvious end goal where the user has to accomplish. While challenging learners' ingenuity (Thiagarajan, 2003), "thinking ahead" strategies are also required in solving puzzles, hence requiring the process of memorization (Williams, 2003). Crossword puzzles designed with different and timed levels of difficulties containing engaging questions as well clues or hints (guide to answers) will be used for meeting the following learning concepts. Concept applications for the color design principles course requires the use of basic terminologies. For example, students need to remember the constituents of primary, secondary and tertiary color families, as well as harmonic relationships like complementary, triadic, or analogous, etc. Discussion questions, design analysis reports and project presentations require that the students utilize and apply the design terms in their answers, analysis and hands-on projects.

Email games. The model of this interactive game designed by Thiagarajan (2003) will be used as a guide to building an online interactive game for color design. The advantage of using this format is that it is simple and do not require any sophisticated programs to build the game. During the activity, players are to collect, distribute and review factual information (referred as the "101 Factoids") related to a job (assignment) relevant situation. During the first round, the learners will receive an email from the facilitator with factual statements related to color design. Content will be organized into categories with supported references to the information. Learners are then required to respond to the email by supplying up to a required number of new factoids by a targeted time and day. The facilitator reviews the email contributions, awards points for each submission, and updates the scores displaying the learners with the highest score along with the list of factoids. The structure of the game format (content, single player or team based, scores and time) may be altered based on the learning objectives for the lesson and structure of online

environment. The key focus of the game is to increase motivation and engage interactivity and teamwork among peers.

Theoretical Implications for DGBL methods

The use of the multimedia components will be applied to enhance the gaming environment for both practice drills and puzzle games. Gardner's theory of multiple intelligences and Gagne's conditions of learning theory will be the focus for the design of module interactivity utilizing multimedia elements such as text, audio, visuals and motion graphics (video). Most of these interactive elements involving the different senses will be applicable for the tutorial module as well as the practice drills and puzzle games. The email games will have minimal theory implications since it is primarily text-based.

Audio or graphics will also function as "attention getters" implicated by Gagne's event of gaining attention. The objectives for each lesson and game directions will be presented via the tutorial and game modules. Simulation of prior learning will be supported with the use of levels, analogy and hints. The programming of game stages from easiest to complex levels may also utilize the concept of Gagne's learning hierarchies. Progress feedbacks (text and graphics) of performances in the form or scores and hints will be included during game play to help motivate the learners. The hints will also function as a guide for sections that may be difficult for challenged learners. Answer selections will be identified with sound effects indicating the choices made. Finally, students will have the choice to replay the game or select repeating levels, as one of the approach to help enhance learning retention.

Bruner's discovery learning theories along with guided discovery concepts are most apparent in the email games since the game focuses on research, and through the engaged activity the learner is able to discover new information. However, the facilitator may practice

prior recall concepts, such as using color terms or keywords from puzzle and drill practices incorporated into task requirement during the play of email games.

Implementation and Evaluation Process

Implementation of the games will be incorporated with lesson materials and course activities. Each lesson will be accompanied with one of the selected games. Practice drills and puzzles will be used to test and enhance vocabulary skills. Email games will be used to target assignments that require higher cognitive form of learning. The instructor or facilitator will be conduct formative and summative evaluations to monitor the effectiveness of the modules and learning outcomes throughout the course.

Conclusion

Gardner's theory of multiple intelligences, Gagne' conditional theories, including the nine events of instruction and learning hierarchies, and Bruner's discovery learning were selected for discussion. These pedagogical theories related to cognitive processing were explored and its implications for digital game based learning were analyzed and presented (see Appendix A-C). In addition, an instructional plan for a web graphics course on the principles of color theory was developed and justified. The course added DGBL modules, a new learning intervention incorporating the selected theories as a guide to meeting improved goals and learning objectives for the course.

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APPENDIX A

Table A1

Summary and analysis of Gardner's theories applied to DGBL in color design course

Gardner's Theory of Multiple Intelligences	Drill & Practice	Puzzles (Example-Crossword Puzzles)	Email Games
Verbal/Linguistic	Written direction for games, questions and answer feedbacks	Written direction for games, questions and answer feedbacks	Email text communication containing Written direction for games, questions and answer feedbacks
Logical/Mathematical	Scores and timers	Scores and timers	Scores and timers
Musical/Rhythmic	Audio used for feedback events	Audio used for feedback events	Non applied
Kinesthetic	Mouse clicks for selection	Keyboard input for text	Keyboard (typing text) and mouse
Visual/Spatial	Graphics representing colors and space can be included as part of the activity	Graphics representing colors and space can be included as part of the activity	Graphics representing colors and space can be included as part of the activity. Can be included into email content, researched answers may contain visual support

Interpersonal	Learner interacts with digital game or team. Builds social relationship with others Scores & hints provide motivation	Learner interacts with digital game or team. Builds social relationship with others Scores & hints provide motivation	Learners interact with facilitator as well as peers. Teamwork is applicable depending on assignment requirement.
Intrapersonal	Growth of self-esteem, able to analyze personal strengths and weaknesses from progress	Growth of self-esteem, able to analyze personal strengths and weaknesses from progress	Growth of self-esteem, able to analyze personal strengths and weaknesses from progress

APPENDIX B

Table B1.

Summary and analysis of Gagne's instructional theories applied to DGBL in color design course

Theory (Nine Events)	Drill & Practice	Puzzles (Example-Crossword Puzzles)	Email Games
Gaining Attention (Reception)	Use of screen design & media in introduction Present questions one at a time (organization)	Use of screen design & media in introduction Present questions one at a time (organization)	Use of text-based description to get learner's attention
Informing learners of objectives	Game instructions will inform learners the purpose of each activity	Game instructions will inform learners the purpose of each activity	Game instructions will inform learners the purpose of each activity
Stimulating recall of prior learning	Use of graphics and hints to guide learner. Increasing level of difficulty can be programmed for each set of drills.	Use of graphics and hints to guide learner. Increasing level of difficulty can be programmed for each set of drills.	Defined within text descriptions. Use items or knowledge learned from drills and puzzles (recall prior learning) and apply to higher level activities
Presenting the Stimulus	Use of scores and feedbacks	Use of scores and feedbacks	Use of scores and feedbacks
Providing Learning	Hints & help files	Hints & help files	Resource links to help search for factoids

Guidance			
Eliciting performance	Interact with game	Interact with game	Learners have to accomplish task from email directions
Providing Feedback	Scores & immediate feedbacks	Scores & immediate feedbacks	Scores & feedbacks provided at the end of each game
Assessing performance	Scores & immediate feedbacks	Scores & immediate feedbacks	Scores & feedbacks provided at the end of each game
Enhancing retention and transfer	Learners can repeat exercises	Learners can repeat exercises	No repetition option avalable

APPENDIX C

Table C1

Summary and analysis of Bruner's Discovery Theory applied to games in color design course.

Discovery Theory	Drill & Practice (Matching Game)	Puzzles (Example-Crossword Puzzles)	Email Games
Exploratory, Experiential Knowledge construction	Feedback hints can offer help to answers at each failed attempt	Feedback hints can offer help to answers at each failed attempt	Discovery of new information during task Knowledge is constructed both individually and as a team during group activities