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ALIGNING INSTRUCTION AND ASSESSMENT WITH GAME AND SIMULATION DESIGN

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ALIGNING INSTRUCTION AND ASSESSMENT WITH GAME AND SIMULATION DESIGN

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Abstract

Effective design of training-related games (games for training and/or assessment) requires synergy between the mechanisms for delivering instructional content and the mechanisms for learning game play and game functionality (Becker, 2006). The learning domain must be embedded as a core game mechanic: that is, the game cannot be advanced or won without utilization of the domain being taught or assessed (Fisch, 2005). To address these issues, we created two interconnected models central to the design and development of training-related games: 1) a Game Play Model comprising the key components of a game and 2) a Player Interaction Framework defining how players interact with information in a game. The model and framework help to optimize the design and development process by providing a shared set of categories for organizing domain and game instruction. They also provide a lens through which comparisons of instructional methods and strategies can be made across games. Using the Game Play Model and Player Interaction Framework, we analyzed 34 games (24 popular commercial video games and 10 commercial video games used by the military). Results of the analyses indicate that while the two game types were similar in the amount of instruction devoted to introducing the various components of the Game Play Model, the delivery mechanisms (the Player Interaction Framework) differed in some key areas. In particular, the military games did not provide enough direct instruction and relied too much on the player to actively seek out information. The Game Play Model and the Player Interaction Framework represent important components in the design and development process for training games and they also provide a useful lens for the examination of the effectiveness of instruction within training games.

Why Game and Domain Instruction Should Be Aligned

There is a strong consensus in the research community that learning outcomes from games are affected by the instructional methods and strategies employed in the games and not by the games in and of themselves (e.g., Garris, Ahlers, & Driskell, 2002; Leemkuil, de Jong, de Hoog, and Christoph, 2003; Thiagarajan, 1998; Wolfe, 1997). More recently, researchers have argued that learning outcomes are dependent on how well the instruction is integrated into the game. Egenfeldt-Nielsen (2006) commented that instructional information should be a natural part of the game dynamics and must be necessary for success in the game. In other words, the act of playing and succeeding at a game should draw directly on the knowledge or skills the game was designed to teach (Fisch, 2005). This means there must be integration with the game's mechanics and in particular, with the game's core mechanics (the actions a player must successfully perform to reach the game's goals).

Wainess and colleagues (Wainess, Iseli, Koenig, Choi et al, 2010; Wainess, Koenig, & Kerr, in preparation) have examined whether the instructional methods and strategies utilized when instructing others how to play entertainment and educational games are the same as those used in teaching educational content. Results of the research suggest they are the same—with one minor difference, regarding the amount of support provided for discovery learning (Wainess et al, 2010). Wainess and colleagues proposed that by understanding when, where, and how effective instructional methods and strategies are used for learning to play a game and by aligning the needs of teaching an instructional domain with the needs of teaching game play, two key benefits can be achieved. First is an alignment of game instruction and learning domain instruction. A second benefit is a reduced cognitive load. The alignment of game instruction and domain instruction supports the growing argument for integration of game and domain learning (Egenfeldt-Nielsen, 2006; Fisch, 2005). Cognitive load (the amount of mental activity imposed on work memory at an instance in time; Chalmers, 2003, Sweller & Chandler, 1994) can be reduced by limiting the amount of germane cognitive load provided in the game (Ayers, 2006). Germaine cognitive load is the cognitive load required by the methods used for presenting new knowledge to a learner (Renkl & Atkinson, 2003). Blending learning the game with learning the content can lead to efficient and effective instruction, as it uses one set of instructions (germane cognitive load) to teach two sets of knowledge: game and learning domain.

The first step to achieving the goals of integration and reduced cognitive load is to map instructional methods and strategies and related constructs to how games teach game mechanics. The hypothesis is that once we understand how games utilize instructional methods, instructional strategies, and other factors that teach how to play a game, we can map those methods and strategies to methods and strategies applicable to teaching specific instructional content (e.g., teaching fractions). By aligning the methods and strategies for teaching game mechanics, tactics, and strategies with the methods and strategies for teaching and practicing instructional content, we propose that we can better control the burdens placed on working memory, thereby improving the learning process and ultimately learning outcomes. Figure 1 shows how game and instructional domain are linked. This paper is focused primarily on the left column (the instructional methods).

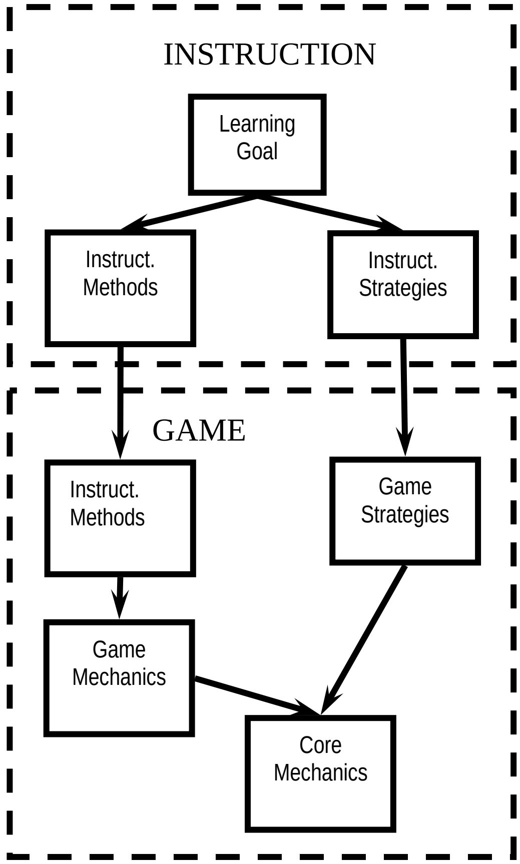

Figure 1. How games and instructional domain are linked.

By beginning with a learning goal (top of Figure 1) and determining effective instructional methods for achieving those goals, a game developer can link those learning domain instructional methods to equivalent instructional methods within games that are utilized for teaching particular game mechanics and ultimately core mechanics. In other words, you would determine the content and how it could effectively be taught. Then, you would determine which type of games mechanics use those same instructional methods and build a game using those mechanics. You would also want to ensure that the game mechanics that are most closely aligned with the learning domain are implemented as core mechanics, so that use of the learning domain becomes critical to game success.

Two Components Important to Improving Instructional Games and Simulations

The University of California Los Angeles' National Center for Research on Evaluation, Standards, and Student Testing (CRESST) has established a methodology for creating games for learning, based on achieving the goals of integrating game instruction and domain instruction and of embedding the learning domain into the core game mechanics. Figure 2 shows the iterative game development methodology. See Wainess & Koenig (2010) for a description of the process.

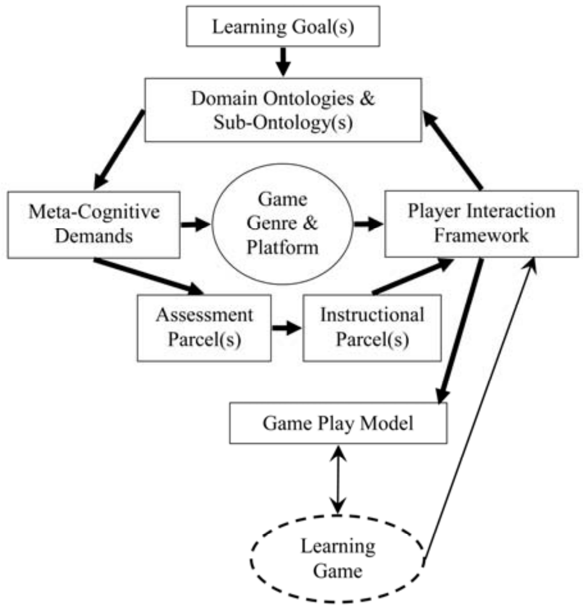

Figure 2. Learning game design and development process.

Two components in CRESST's design and development methodology (Figure 1) are relevant to this paper.

1. The Player Interaction Framework
2. The Game Play Model

Player Interaction Framework

Figure 3 shows the Player Interaction Framework. The framework depicts how a player interacts with information (instruction and assessment) in a game space. More specifically, it illustrates the ways in which information (domain content and instruction, and assessment items) is either presented to the player or how the player can seek out information.

Presentation objects refer to instruction directly presented to the player (e.g., a dialog box with instruction).

Background objects refer to information or instruction that is covertly integrated into the environment and requires the player to actively pursue (seek out) the information (e.g., relevant information on a poster on the wall in a hallway alongside other posters that may not contain relevant information).

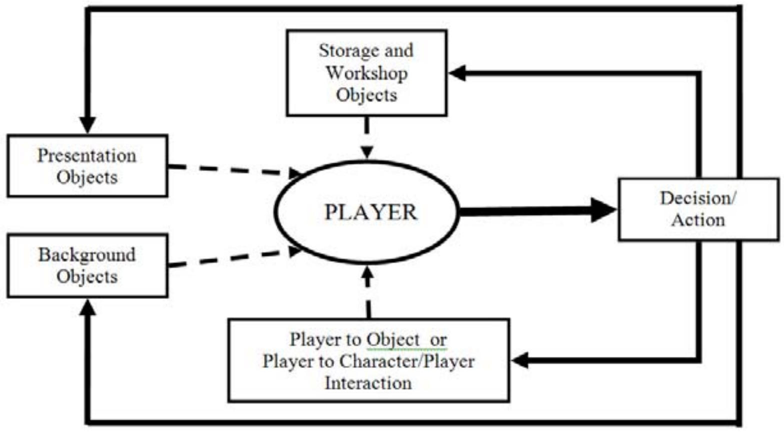

Figure 3. Player Interaction Framework.

Person-to-object interaction and person-to-character/player interaction are similar. The object or person is highlighted (visually emphasized), cueing the player that the object or person is important and should be interacted with (e.g., a "glowing" object on a table).

Storage and workshop objects refer to a group of functions that would typically be separated from the main game space in order to view items collected (resources), manipulate or combine resources, or search for additional information or resources.

Game Play Model

The Game Play Model (Figure 4) illustrates the relationships among the components of a game and is linked to the instruction by the player interaction framework. For a complete discussion of this model, including how it integrates with the player interaction framework, see Wainess & Koenig (in preparation).

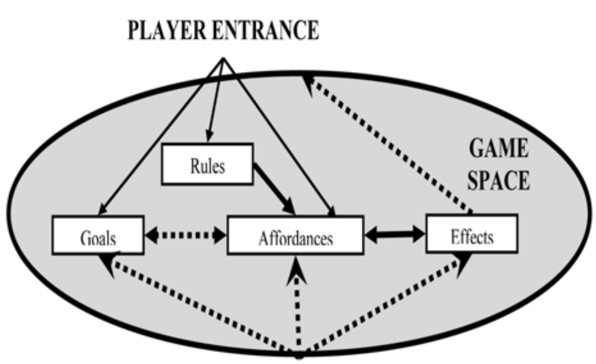

Figure 4. Game Play Model.

According to the Game Play Model, a player enters a *game space* governed by *rules*. The player is given a *goal*. The player possesses pre-existing *affordances* (prior knowledge, prior skills, self-beliefs, attitudes, etc.) that may or may not be beneficial in the game. The player may also bring with or act upon his or her own goals. The player is represented by the term *affordances*, as the affordances represent the current abilities of a player in the game. The player's actions may cause *effects* in the game that may a) alter the player's affordance and/or b) alter the game space. Changes to the game space may change the game goal(s) and/or the player's affordances, and may eventually cause additional effects, which might in turn alter the player's affordances and/or the game space.

The Player Interaction Framework (Figure 3) and the Game Play Model (Figure 4) are the basis for the research and recommendations in this study.

Methodology

This paper utilizes a descriptive study with coding of learning events and comparison of two game types: commercial video games used by the military and popular commercial video games not used by the military. Ten commercial video games used by the military (Table 1) were analyzed and coded for how game features were taught.

Table 1

Commercial Video Games Used by the Military

Game	Platform	Branch
Air Force Delta Storm	XBOX	Air force
Arma II: Ultimate Military Simulator	PC	Marines
Battlefield 1942	PC	Army
(Jane's) Fleet Command	PC	Navy
Steel Beasts	PC	Army
Medal of Honor: Frontline	PS2	Marines
Medal of Honor: War Chest	PC	Marines
Operation Flashpoint: Dragon Rising	PC	Army
SOCOM: US Navy Seals	PS2	Navy
Soldier of Fortune: Payback	PC	Marines

Introduction of three game features (game mechanics, game controls, and game interface) were coded for interaction method (Figure 3) and game play component (Figure 4), as well as for a wide range of instructional features, including instructional method and strategy, type of feedback, and metacognitive support.

Table 2

Popular Commercial Video Games Coded and Analyzed for the Present Study

Name of game
Animal Crossing
BATTLEFIELD2 Modern Combat
Call of Duty 2
Dark Void Demo
Elite Beat Agents
Final Fantasy Tactics
FolkLore
Genji: Days of the Blade
Ghost Recon Advance War Fighter
Halo
Heavenly Sword
Hot Shots Golf: Out of Bounds
Kill Zone 2
Kung Fu Panda
Little Big Planet
Loco Roco 2
Motor Storm
Perfect Dark Zero
Pokemon Pearl
Ratchet & Clank: Futute: Tools of Destruction
Resistance 2
Spyro: The Eternal Night
Uncharted 2: Among Thieves
Worms: Open Warfare

Twenty-four popular commercial video games (Table 2) were also analyzed and coded. Codes for the two game types were examined and compared, using descriptive statistics, including frequency and percentages.

According to Wainess et al. (2010), *game mechanics* are the actions a player can do, governed by the rules of the game. *Game controls* are the mechanisms by which a player can interact with a game. Game controls for video games include button presses, mouse clicks, joy stick movement, and even body movement. *Game interface* refers to the elements or tools a player can see, that allow the player to make choices related to a game (load/save, select a particular weapon), view the player's current state (e.g. a health bar, number of bullets remaining in a clip), and view the world's state (e.g, access maps, view a radar showing enemy locations). The game interface is the link between the player and the game world.

Instructional methods are external supports for metacognitive processes. For example, use of analogies is an instructional method. Use of worked examples is another instructional method. *Instructional strategies* are approaches to learning and can benefit from the inclusion of instructional methods. Group exercises and lectures are examples of instructional strategies. Both group exercises and lectures (instructional strategies) can utilize analogies and worked examples (instructional methods).

Sample

Two groups of games were examined in this study: popular commercial video games and commercial video games utilized by the military. In some cases, a commercial game utilized by the military was also a popular commercial video game (e.g., SOCOM: U.S. Navy Seals). In those instances, the game was included in the military video game analyses and not in the commercial video game analyses.

Commercial video games utilized by the military were selected from a list of 66 games identified by the Department of Defense Game Developer's Community as having been used for military training (http://adlcommunity.net/mod/data/view.php?id=663). Of the 66 games listed on the website, only 13 were selected for this study. We were unable to locate many of the games, due to the age of the game. Others games were not included because of the cost of the game (e.g., base price for Virtual Battle Space II was $1,500). Others were not obtainable, such as Avant Guard, by the Air Force Research Lab, Human Effectiveness Directorate.

Training the Coders

Two researchers were trained on how to analyze and code video games. Each of the games was analyzed and coded by only one researcher. To validate the reliability of using a single coder, two of the games were examined independently by both coders. The coders then reviewed their codes with each other and marked all entries as 1 (agreed to) or 0 (not agreed to). The two games analyzed by both coders were Call of Duty 2 (a popular commercial game) and SOCOM: US Navy Seals (a commercial video game used by the military).

Table 3

Instructional Codes

Component taught	Percent agreement
Component taught	85
Player interaction framework: presentation	87
Player interaction framework: background	99
Player interaction framework: person-to-object	87
Player interaction framework: workshop	99
Element taught: mechanic	93
Element taught: control	93
Element taught: interface	96
Re-exposure: repetition	92
Re-exposure: elaboration	94
Instructional strategy: guided learning	92
Instructional strategy: unguided learning	96
Instructional method: part task	72
Instructional method: part whole task	82
Instructional method: whole task	95
Pre-training	91
Just-in-time training	97
Worked example	99
Feedback: implicit	55
Feedback: simple explicit	92
Feedback: elaborated explicit	100
Metacognitive support: implicit goals	80
Metacognitive support: explicit goals	88
Advance organizer	78
Cueing and pointers	87
Resource list	86
Task list	79

Table 3 lists the codes that were used in the analyses and the percent agreement for each code. Because 70% or greater represents an adequate level of reliability, and only the agreement for implicit feedback fell below 70% (it was 55%), only that item was examined for cause. It was discovered that one rater was over coding for feedback by coding direct instruction as implicit feedback. The coder was taught the difference between instruction and feedback. Due to the high level of agreement (26 of 27 items exceeding 75% agreement), it was determined that only one rater would be needed to analyze each game of the remaining 32 games.

Table 4

Relationship of Components Taught to Game Play Component

Components taught	Game play component
Rule	Rule
Psychomotor skill	Affordance
Task	Goal
Tool	Affordance
State	Affordance
World space	Game space

As shown in Table 3, the games were analyzed for a wide range of game and instructional features. The first 5 rows of the table represent the elements of interest in this paper. *Component taught* refers to the components of the Game Play Model (Figure 4). There were six possible components that could be taught (Table 4). Note there is no component related to *effect* (see Figure 4), as effects are a reaction to what a player does, rather than what the player is capable of doing; that is, it is not an affordance, but rather, the result of an affordance. The four Player Interaction Framework items in Table 3 refer to the four ways in which the player can interact with information or how the information can be presented to the player, as illustrated in the Player Interaction Framework (Figure 3). Agreement percentages for game component taught and interaction method ranged from 87 percent to 99 percent, indicating highly reliable agreement by the two coders.

Analyses and Results

The analyses focused on how the six game components (Table 4) were taught. To ensure the two game types were similar enough in their instructional needs in order to allow for comparison, the percentage of instructional time devoted to each of the six game components was compared (Figure 5). Popular commercial games and commercial games utilized by the military appear to differ in the amount of instruction devoted to world space, constraints, and tasks. However, with the exception of game constraints (8.1% versus 3.3%), the bulk of instruction on *game mechanics* (which is composed of state, tools, constraints, and psychomotor skills) is equivalent across the two game types. Since constraints represent the smallest portion of the game mechanics-related instruction, it appears as though the two game types are similar enough in how they teach game mechanics to allow for comparison. Therefore, the remaining analyses will be devoted to instruction of psychomotor skills, tools, and state-related components.

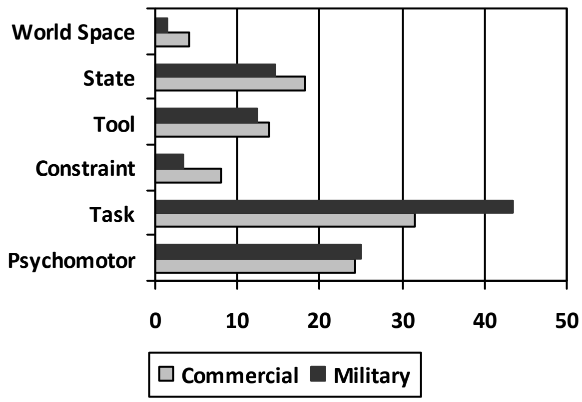

Figure 5. Percent of instruction devoted to game component by game type.

Figure 6 shows that both game types (military and commercial) delivered equivalent amounts of instruction using guided learning.

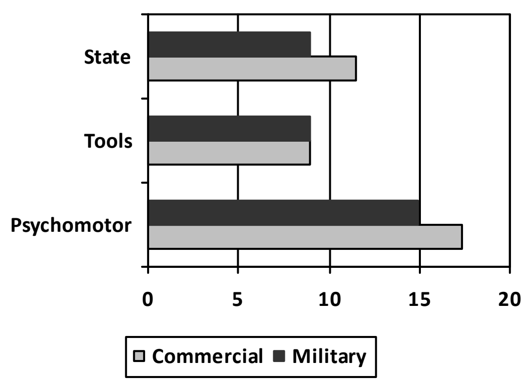

Figure 6. Percent of guided learning.

As can be seen in Figure 7, military games devoted more time, compared to commercial games, to unguided learning, particularly when teaching tools and state-related components; however, tools and state-related components comprised very little of the instruction presented in the game.

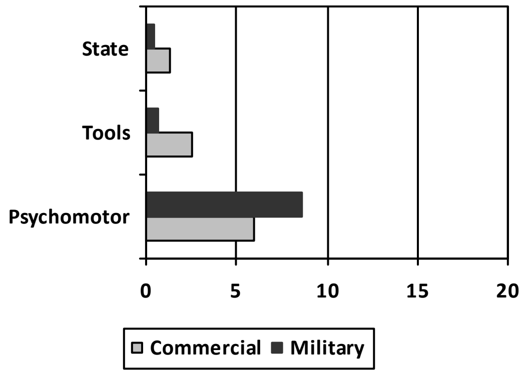

Figure 7. Percent of unguided learning.

Figures 8 through 11 depict the amount of instruction delivered via the four types of player interactions (see Figure 3). Figure 8 shows that commercial games used direct instruction (presentation objects) twice as often as military games, in order to teach psychomotor skills.

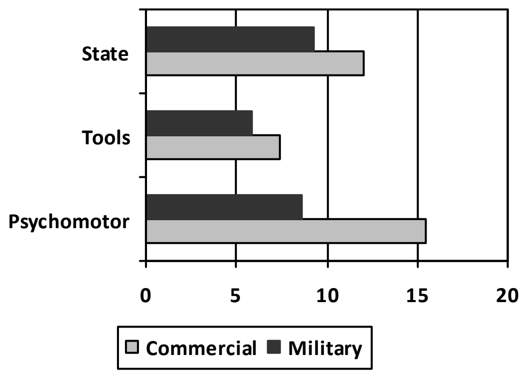

Figure 8. Percent of instruction delivered via presentation objects.

Figure 9 shows that military games used background objects five times as often as commercial games to introduce state-related tools. In other words, it was up to the player to discover the tools because the game did not point them out.

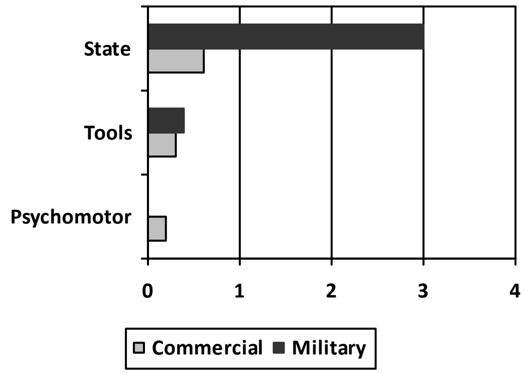

Figure 9. Percent of instruction delivered via background objects.

Figure 10 shows that military games used person-to-object interactions three times as often, as compared to commercial games, to introduce psychomotor skills. Figures 8 and 10 indicate that military games relied on the player choosing to interact with instructional objects to learn about psychomotor skills, while commercial games delivered the same type of instruction directly to the player, without requiring the player to seek it out. That is, commercial games ensured the player was exposed to the instruction while the military games did not.

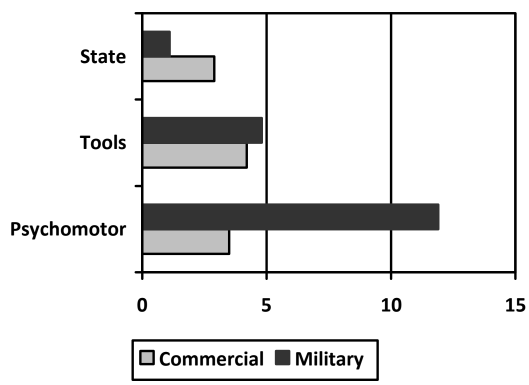

Figure 10. Percent of instruction delivered via person-to-object instruction

Figure 11 shows that workshop objects were only used by military games for teaching psychomotor skills. Workshop objects were used by commercial games to teach all three game mechanic-related game components.

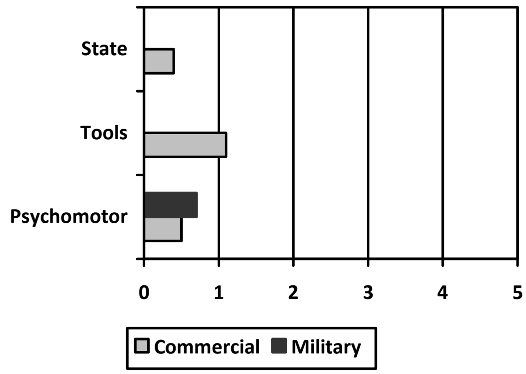

Figure 11. Percent of instruction delivered using workshop functions

Discussion

The analyses indicate that, while popular commercial games and commercial games used by the military are similar in the amount of instruction devoted to the various game play components (see Figure 5), they differ in how they teach those components. Both game types used equivalent amounts of guided learning (see Figure 5), which research has shown is important to learning (e.g., Kirschner, Sweller, & Clark, 2006). Commercial games used a greater amount of unguided learning, compared to military games, in order to teach tools (e.g., a weapon) and state-related components (e.g., a health bar), which supports the trial and error appeal of commercial video games.

Some problems with the way military games taught how to play a game appeared when the methods for delivering the instruction were examined. Presentation objects directly deliver instruction; background objects obscure instruction; and person-to-object interactions require the player to actively seek instruction. Military games fall short of commercial games in directly teaching (presentation objects) psychomotor skills (see Figure 8), requiring instead that players seek out the instruction (person-to-object interactions, see Figure 10). When it comes to providing players with tools to monitor their condition (state), military games tended to blend that information into the background and relied on players awareness and curiosity to discover the components and how they function (see Figure 9). Finally, military games made very little use of workshop functions, which are tools that allow the player to see his or her status and resources, to manipulate those resources, and to seek out additional information or resources.

Implications

One of the reasons popular commercial video games are popular is they are able to teach players how to play the game. In a market filled with competitors, these games have managed to engage the largest share of the market. If these games were difficult to learn, they would likely not have achieved that status. Research suggests the importance of integrating game learning with content learning, if we are to build effective learning environments that require using what was learned as a game feature (a game mechanic) and, at the same time, reduce cognitive load. The military games analyzed in this paper suggest that they used methods and strategies that were counter to those utilized by popular commercial games. If military game developers are to succeed at creating a training game that is both successful as a game and as a learning environment, they will need to rethink design. They will have to blend the delivery mechanisms of the learning domain with the delivery mechanisms of the game instruction, rather than the other way around. As was highlighted in this paper, currently, if blending does occur, the game is blended with the instructional domain, rather than the other way around. The blending is occurring in the wrong direction.

The current trend that military games use background objects and person-to-object interactions increases the likelihood that the learner will not receive the intended instruction. From the research presented in the paper, the following design recommendations are suggested for creating military training games.

1. Increase direct instruction (use of presentation objects) for teaching psychomotor skills in the game
2. Increase direct instruction (use of presentation objects) for introducing state-related components
3. Reduce the use of background objects for introducing state-related components
4. Reduce the use of person-to-object interactions to introduce psychomotor skills

This paper highlighted the relevance of examining game instruction in relation to the Player Interaction Framework (Figure 3) and the Game Play Model (Figure 4). The remaining 23 instruction-related elements listed in Table 3 need to be examined as well, in relation to the Player Interaction Framework and the Game Play Model. Examination of each of the remaining elements is likely to illuminate additional differences between how popular commercial video games teach compared to how commercial video games utilized by the military teach. The findings presented in this paper are one step in the direction towards the effective integration of game instruction and domain instruction (see Figure 1).

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